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(NASA-TM-80013) OAST SPACE THEME WORKSHOP. VOLUME 3: WORKING GROUP SUMMARY. 6: POWER (P-2). A. STATEMENT. B. TECHNOLOGY NEEDS (FORM 1). C. PRIORITY ASSESSMENT (FORM 2) (NASA) 123 p HC A06/MF A01 CSCL 22A G3/12

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OAST SPACE THEME WORKSHOP

VOLUME III

WORKING GROUP SUMMARY

VI. POWER (P-2)

A. STATEMENT

B. TECHNOLOGY NEEDS (FORM I)

C. PRIORITY ASSESSMENT (FORM II)

HELD AT THE
LANGLEY RESEARCH CENTER
APRIL 26-30, 1976

SPONSORED BY NASA-CODE RX

Foreword

The attached material represents the working papers from the OAST Space Theme Workshop held at the Langley Research Center, April 26-30, 1976, and contains a quick-look analysis of the proceedings. The material is unedited and intended for further use by the participants of the workshop and the planning elements of NASA concerned with space mission research and technology. It should be understood that the data do not represent official plans or positions but are part of the process of evolving such plans and positions.

Nearly 100 of the Agency's top technologists and scientists joined with another 35 theme specialists to produce this working document - a document that provides a technical foundation, including research and technology base candidates, for each of the six space themes.

The material in this report is considered essential to the development of Center initiatives in support of these themes. Copies of the report will be made available to the Center Management Board and the individuals at the Centers responsible for the FY'78 program planning cycle. The timing of this planning activity has caused us to distribute this document in this unedited form. Thus, it possibly contains errors, hopefully, more of a typographical rather than a technological nature. Nonetheless, the information contained is of a high professional level, reflecting the efforts of the workshop participants and will be invaluable to the planning and successful execution of the Agency's near- and far-term advanced technology program.

Stanley R. Sadin
OAST Space Theme Workshop
Chairman
NASA Headquarters
Study, Analysis, & Planning Office
Office of Aeronautics and
Space Technology

MULTIPURPOSE SPACE POWER PLATFORM 7

INDUSTRIALIZATION OF SPACE #8

The requirements identified for Theme 7 (MPPS) & 8 were divided into three time frames in order to identify and assign priorities to technology items. The first flight time of 1983 dictated that technology be presently in hand or a low risk development. However, three new initiatives were identified including an accelerated flight of Sphinx B/C. Flight time of 1988 with its higher power levels required higher voltage and power components with longer life and lighter weight. This required four new initiatives to meet the requirements. The 2000 launch with its multi-megawatt requirements requires several new initiatives including new concepts in power transmission and distribution. The use of themes and discussions with the team was helpful in focusing the future power requirements os that the technology could be more easily identified.

POWER REQUIREMENTS - MSPP(#7)

LAUNCH DATE	1983	1988	2000+
• ORBIT LOCATION	LEO	GSO(P); LEO (S)	GSO
• POWER - KW	100(P) 200(S)	1,000	10,000
• VOLTS - DC	120	120	440
• LOADS	OFF-THE-SHELF HARDWARE	20 KV LASER PROPULSION; INDUSTRIAL	LASER PROP; HABITAT; M'F'G
• LIFE - YRS.	5	10	30
• AUTONOMOUS	YES	YES	YES
• MAINTENANCE	BY MAN	BY MAN	BY MAN
• PROPULSION	STATION KEEPING	SAME	• SAME • POSSIBLE ORBIT TRANSFER

(P) PRIMARY

(S) SECONDARY

POWER REQUIREMENTS - INDUSTRIALIZATION OF SPACE (#8)

LAUNCH DATE	1983	1988	2000
o POWER - KW	10s	10^3	TO 10^5
o VOLTS - DC	120	120	100
o LOADS	-	-	1000 OUTLETS
o ORBIT	LEO	LEO, GSO	LEO, GSO, LUNAR BASE (100 MEN)
o LIFE-YRS	5-10	10-15	25-30
o AUTONOMOUS	YES	YES	YES
o MAINTENANCE	YES	YES	YES
o PROPULSION	STATIONKEEPING	SAME	SAME

POWER NEEDS FOR SETI #9

The SETI theme proposes three space-antenna systems with diameters of 30 meters for 1984, 300 for 1990, and 3000 for 2000. The first version will orbit geosynchronously; the others, at lunar distances in half-time shadow with a 29.3-day cycle. The latter two systems will require once-a-year reorientation at 1^{o} per day: $\pm 2^{o}$ for the 300-meter antenna and $\pm 7^{o}$ for the 3000-meter one. Each dish has an RFI shield twice its diameter on its earth-facing side and antenna feed on its deep-space-facing side. Both the shield and antenna feed are located half dish radii from the dish surface on the system axis. Fully supported shield and dish surfaces might have thicknesses of the order of a milimeter. So these will be very large, very fragile, very deformable systems that will utilize periodic low-acceleration propulsion to repoint the dish, shield, and antenna feed as a whole.

The SETI space-system problems are unusual and difficult: For the geosynchronous orbit, environmental-charging technology is of prime importance. Uncontrolled arcing will cause RFI as will conventional controlled-beam discharges. So Sphinx B/C findings will be extremely valuable. Cost effectiveness and long lifetimes will make economical, light-weight, radiation-resistant solar-cell arrays (NI) necessary. And the uncommon aspects of SETI propulsion, cryogenics, and electrical-storage cycles require regenerative fuel-cell techology. Because SETI systems must operate essentially autonomously, they need automatic management, remote control, and advanced electronic conditioning of power, which are ongoing technological programs. As backups to a specifically adapted solar-cell, regenerative-fuel-cell power systems, OASIS (NI) and the nuclear thermionic pwoer module should also be considered for SETI.

The fragile, extensive geometries; the shadow, propulsion, and storage cycles; RFI elimination; and economy and lifetime requirements of the SETI space-antenna systems result in these diverse, demanding power needs.

POWER REQUIREMENTS - SETI (No. 9)

LAUNCH DATE	1984	1990	2000
• POWER - KW	2	3-PLUS PROPULSION	10
• VOLTS	?	?	?
• SPECIAL LOADS	-	ORDER OF MEGAWATT FOR SHIELD AND DISH PROPULSION	-
• ORBIT	LEO/GSO	GSO/LUNAR DISTANCE	GSO/LUNAR DISTANCE
• UNIQUE ENVIRONMENT	o S/C CHARGING o HALF TIME SHADOW	SAME SAME	SAME SAME
• LIFE - YEARS	10	10	30
• AUTONOMOUS	YES	YES	YES
• MAINTENANCE	YES	YES	YES
• PROPULSION; ORBIT TRANSFER AND POSITIONING	YES	YES	YES
• SPECIAL EMI;RFI;ETC.	YES	YES	YES

FACILITY THEME #10

The Solar Exploration Theme (#10) emphasizes the development and operation of an Outer Planet Study Facility (Space Vehicle) with the initial one in Earth orbit launched in 1990 followed by the planetary facility in 1995. Significant drivers are the requirements for: (1) propulsive power (hundreds of Kw) and science (tens of Kw); (2) extremely long-life (10 to 20 years); capability of operating autonomously in the orbiting facility and supporting craft (free-flyers, landers, probes, sample-return); (4) providing power to the supporting craft under extremely severe Jovian environmental conditions (low temperature on surface, high "g" impact for penetrators, high natural radiation environments using RTG's and batteries and associated power processing equipment for regulation, conversion, and control).

These requirements create the need for the following technology support efforts: (1) Nuclear-thermionic development to supply the high power requirement and Solar Electric Propulsion for Low-Earth-Orbit to Geo-Synchronous Orbit; (2) Automated Power Systems Management Technology, which is essential because it provides automatic load control, self-test and repair capability, system health checks, power margin determination to avoid unintentional overloads, and fault-clearing; (3) Advances in power processing for planetary missions in order to raise low voltage thermionic diode power to kilovolt levels for NEP thruster systems and to work with support craft RTG's and batteries under the severe environments identified, which are critical technology drivers; (4) advances in automatic test techniques to checkout the autonomous power management function, redundant power processing, and long-life batteries which must be carefully maintained for up to 20 years; (5) advanced long-life, high performance batteries for the orbiters, probes, penetrators, landers, and rovers. Surface craft will require batteries of capable of very low temperature operation, being rechargeable, dilivering high peak powers; (6) an advanced thermoelectric technology that provides capability of 20 year predictable performance with graceful degradation, and high "g" impact capability for penetrators; and (7) advanced solar array technology including improved solar cell capability and solar arrays for the Solar Electric Propulsion System - which is a precursor to Nuclear Electric Propulsion. SEP may also be used to raise the Earth Exploration facility from LEO to GSO.

Two new initiatives are planned: for Nuclear Thermionics and Advanced Power Systems Technology to achieve improvements in systems, storage, and power processing.

POWER REQUIREMENTS - EXPLORATION FACILITY (#10)

LAUNCH DATE	1990	1995
• ORBIT LOCATION	EARTH	OUTER PLANET
• POWER - KW [PROP + SCIENCE]	200	500
• VOLTS	≤200, 1000	SAME
• REGULATION [SCIENCE]	1%	SAME
• LIFE - YRS	≤10	20
• AUTONOMOUS	YES	YES
• MAINTENANCE	MAN	RESUPPLY, SAMPLE-RETURN
• PROPULSION [ORBITER]	SEP OR NEP	NEP
• ENVIRONMENTS		
- RADIATION	LEO TO GEO, NEP	NEP, JUPITER
- OTHER PLANETARY		-150°K, HIGH G
		IMPACT, RFI
• FACILITY SUPPORT	FREE FLYER	FREE FLYERS (RTG)
		PROBES (RTG, BATT'Y)
		LANDERS (RTG, BATT'Y)
		SAMPLE-RETURN (RTG, BATT'Y)

*YEAR 2000 STUDY FACILITY UNDEFINED

GLOBAL SERVICE SYSTEMS #11

The Global Service Systems theme, from a power point of view, drives orbiting power systems in Low Earth Orbit from 20 Kw in 1983 to 50 Kw in 1988 to 500 Kw by the year 2000. For Geosynchronous Orbit a 20 Kw system is needed from 1983 on. Progressively longer lives of from 3-5 years to 10-20 years with autonomous operation becoming more important in 1988 and beyond. It is apparent that sensor-instrumentation servicing of at least one time per year through the 1988 period will be needed. Maintenance and refurbishment of the power systems may, therefore, be feasible and could place less stringent demands on system life and reliability.

Technologically, this theme requires evolving solar array, energy storage, power conditioning and distribution technologies. The priorities were established on the basis of the relatively near term requirements. Some technologies that become significant in the long-term such as autonomous control, regenerative H_2/O_2 fuel cell and very high energy density battery storage systems do not appear in the negotiated priority assessment for this theme.

POWER REQUIREMENTS - GLOBAL SYSTEMS (#11)

LAUNCH DATE	1983	1988	2000
• POWER - KW (ORBIT)	20 (LEO)	20 (LEO) 50 (GSO)	500 (LEO) 2J (GSO)
• VOLTS - DC	120, HIGHER FOR SENSORS	SAME	SAME
• STORAGE FOR ECLIPSES	YES	YES	YES
• UNIQUE ENVIRONMENT	-	SPACECRAFT CHARGING	YES
• LIFE - YEARS	3 - 5	3 - 5 LEO 5 - 10 GSO	10 LEO 20 GSO
• AUTONOMOUS	NO	PARTIAL	TOTAL
• MAINTENANCE	ONCE/YEAR	ONCE/YEAR	ONCE IN 3 YEARS
• PROPULSION	STATION KEEPING	SAME	SAME
• EMI, RFI	- QUIET PREFERRED	ORBIT TRANSFER? SAME	SAME SAME

ADVANCED SPACE TRANSPORTATION SYSTEMS #12

The Space Transportation Systems (STS) addressed in this theme include Shuttle, Spacelab, Interim Upper Stage, and an advanced upper stage such as the Solar Electric Propulsion Systems (SEPS). The principal electrical power requirements for this theme are associated with the Solar Electric Propulsion System. Therefore technology requirements addressing the specific needs of an electric space tug and OTU were formulated. Key technology drivers identified were light-weight fuel cell development, unique and advanced solar array technology for solar electric propulsion, lightweight fuel cell development and nuclear electric propulsion. It was noted that the MSPP theme 7 has direct applicability to STS.

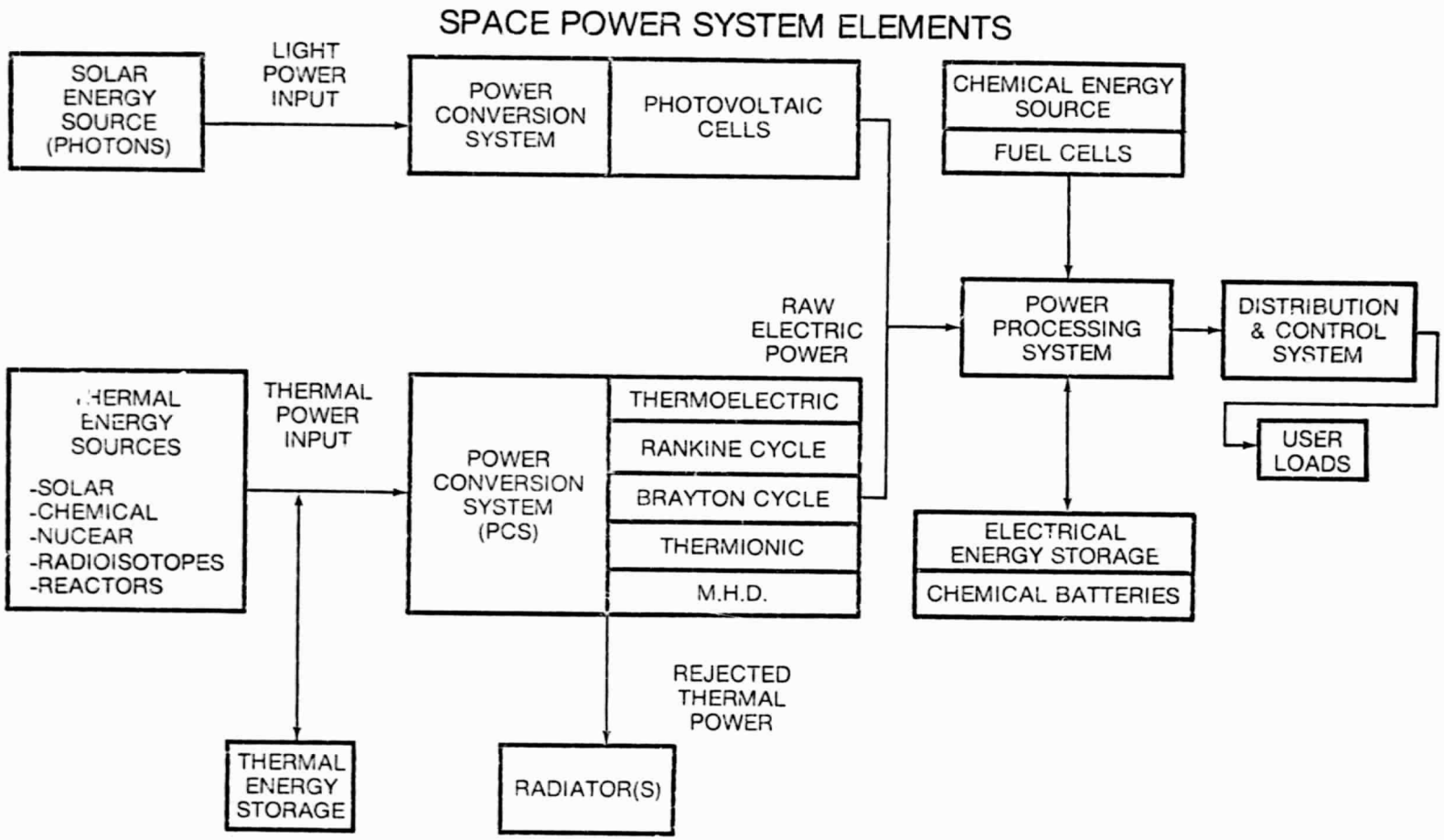
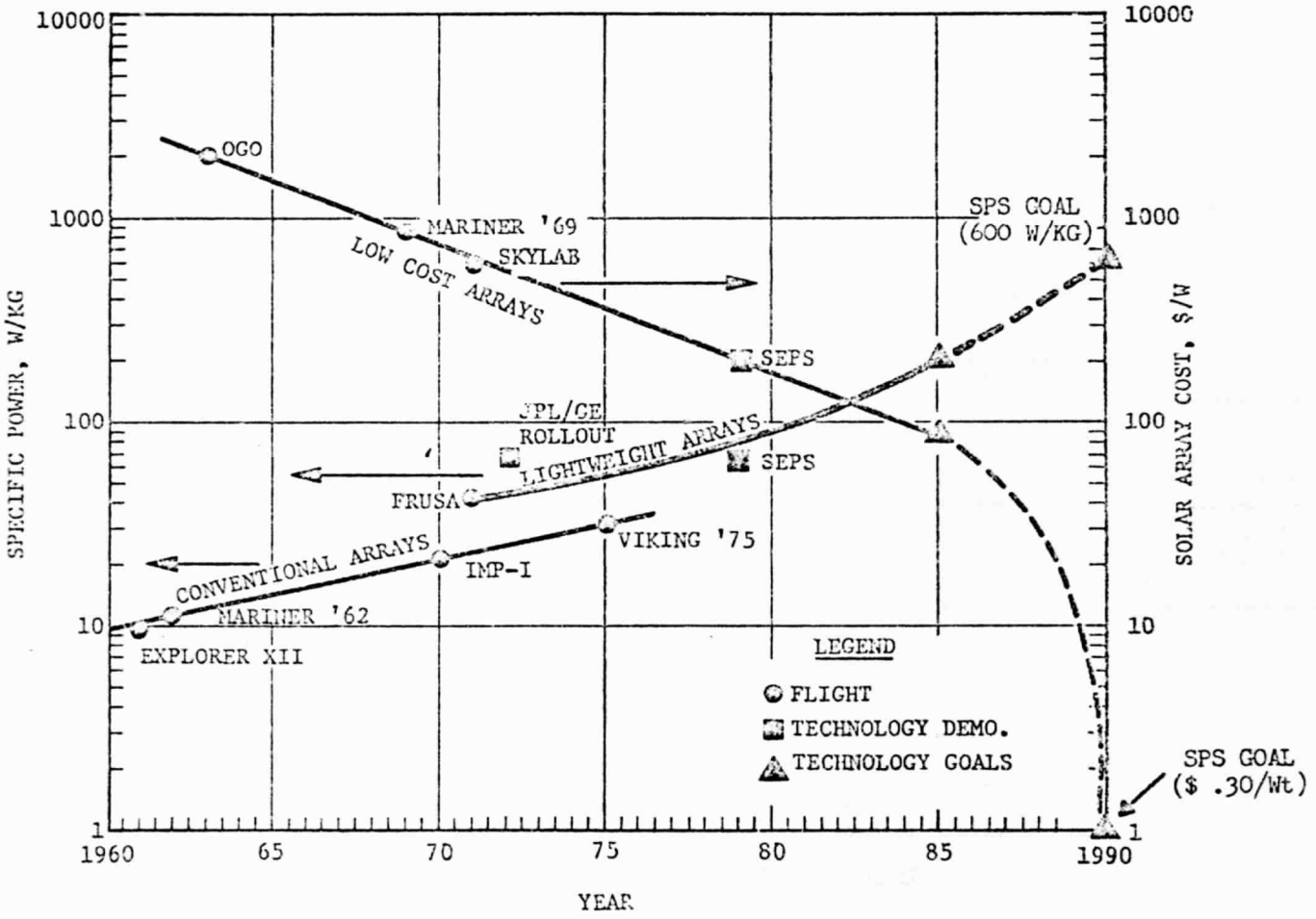

SPACE POWER SYSTEM ELEMENTS
SOLAR ENERGY SOURCE (PHOTONS)
LIGHT POWER INPUT
POWER CONVERSION SYSTEM
PHOTOVOLTAIC CELLS
CHEMICAL ENERGY SOURCE
FUEL CELLS
RAW ELECTRIC POWER
POWER PROCESSING SYSTEM
DISTRIBUTION & CONTROL SYSTEM
USER LOADS
THERMAL ENERGY SOURCES
-SOLAR
-CHEMICAL
-NUCEAR
-RADIOISOTOPES
-REACTORS
THERMAL POWER INPUT
POWER CONVERSION SYSTEM (PCS)
THERMOELECTRIC
RANKINE CYCLE
BRAYTON CYCLE
THERMIONIC
M.H.D.
ELECTRICAL ENERGY STORAGE
CHEMICAL BATTERIES
REJECTED THERMAL POWER
THERMAL ENERGY STORAGE
RADIATOR(S)

FIG. 1

HIGH POWER DENSITY SOLAR ARRAYS



REGION OF APPLICATION FOR SPACE NUCLEAR REACTOR POWER

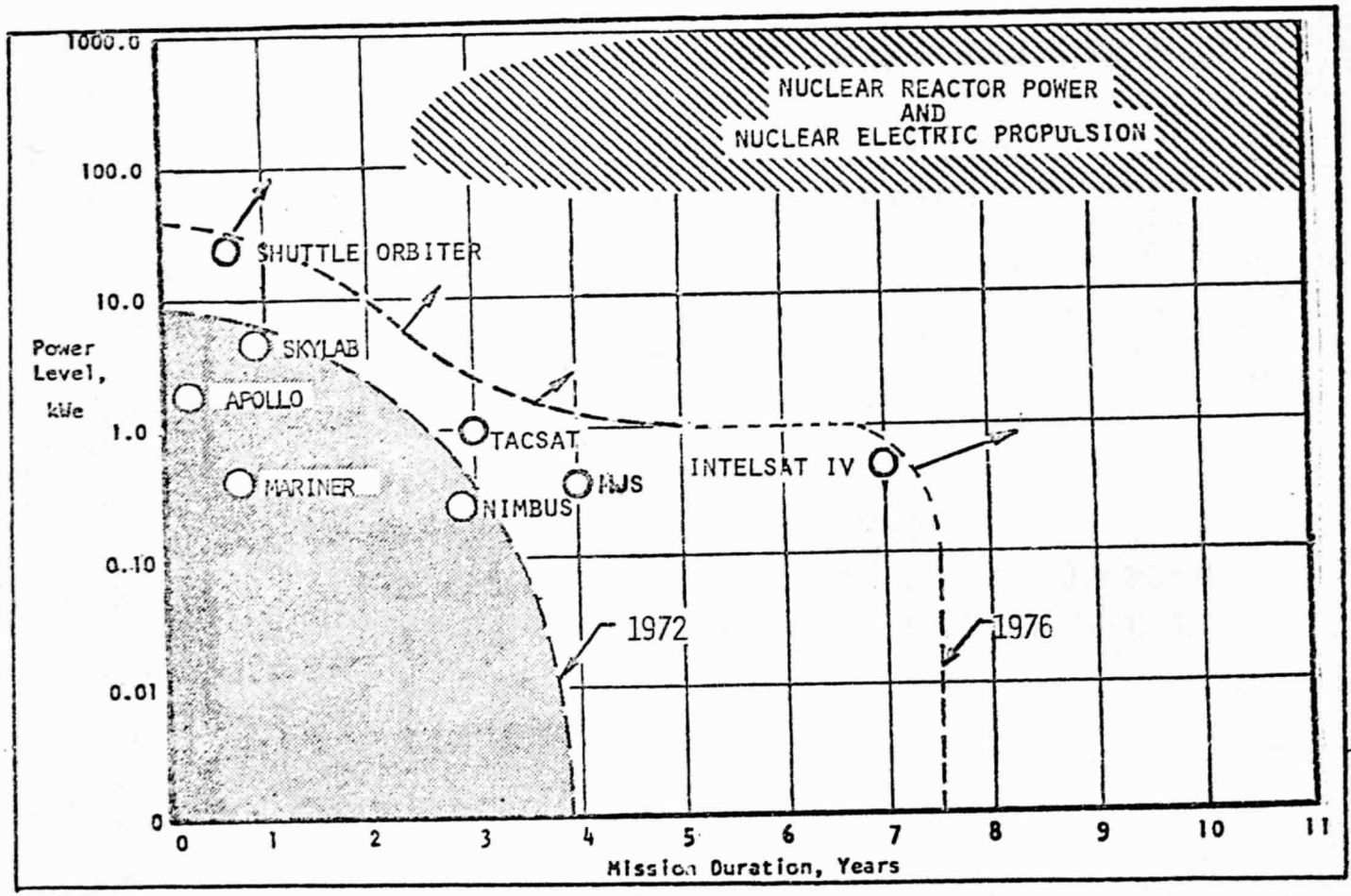


FIG. 3

BASELINE SPACE POWER PROGRAM
1980-85

10's OF KW
(LEO)

ON-GOING TECHNOLOGY

- SOLAR ARRAYS (67 W/KG)
- ISOTOPE BRAYTON ($\leq$ 25 KW)
- LT.WT. Ni-Cd BATTERY (50-60 W HR/KG & 20 Ah CELLS)
- $\leq$ 400 V. POWER PROCESSING & 120 V D.C. DISTRIBUTION
- AUTOMATED POWER SYSTEM MANAGEMENT
- MICROWAVE TRANSMISSION
- ENVIRONMENTAL INTERACTIONS

NEW INITIATIVES (FY 78)

- OASIS
- SPHINX B/C
- Ni-Cd BATTERY SCALING (100 Ah CELLS)
- Ag-H. RECHARGEABLE BATTERY (88 W HR/KG)
- HIGH VOLTAGE DISTRIBUTION
- EXPANDED AUTOMATED POWER SYSTEM MANAGEMENT FOR UNIQUE THEME LOADS
- MICROWAVE TRANSMISSION (SPACE BASED)
- HIGH TEMPERATURE SOLAR ARRAY

FIG. 4

BASELINE SPACE POWER PROGRAM

1990-95	2000
100's OF KW (LEO & GSO)	10's OF MW (GSO)

ON-GOING TECHNOLOGY

- ADVANCED SOLAR ARRAYS (200 W/KG)
- THERMIONIC CONVERSION (NUCLEAR)
- HIGH ENERGY DENSITY BATTERY (88 TO 200 W HR/KG)
- HIGH POWER/HIGH VOLTAGE POWER PROCESSING AND DISTRIBUTION
- ENVIRONMENTAL INTERACTIONS
- LASER TRANSMISSION
- AUTOMATED POWER SYSTEM MANAGEMENT

NEW INITIATIVES

- RADIATION RESISTANT SOLAR ARRAYS
- REGENERATIVE H/O FUEL CELL
- HIGH TEMP BRAYTON POWER CONVERSION
- RADIATION RESISTANT SOLAR CONCENTRATOR
- POWER PROCESSING FOR THERMIONIC CONVERSION
- LASER POWER TRANSMITTER & CONVERTER
- MW POWER SYSTEM INTERACTIONS
- ADVANCED POWER SYSTEM

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE PHOTOVOLTAIC CONVERSION

HIGH-TEMPERATURE SOLAR ARRAYS

NO. 7,10/P-2/PC-1
THEME / W.G. / TASK

DATE 4 / 29 / 76

2. OBJECTIVE

Develop a high performance, high temperature solar array for near sun and the high temperature environments

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1983]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Technology Development (Check one or more)

f) R&T BASE CANDIDATE FY 76: 506-23-12, $0, NI Candidate FY'78

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop an array using a solar cell appropriate for a high temperature environment of +240° C and cycle life of 5600 cycles between +240° C and -100° C.

LEVEL OF STATE OF ART

1. COMPONENT OR BREADBOARD VALIDATED IN LABORATORY ENVIRONMENT
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERFORMANCE OR CHARACTERISTICS DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Photovoltaic Conversion Lightweight Radiation-Resistant Solar Arrays

NO. 7, 8, 10/p-2 /PC-2
THEME / W.G. / TASK

DATE 4 / 26/ 76

2. OBJECTIVE
To develop thin, lightweight, radiation resistant, low-cost solar cells.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1988]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] Technology development (Check one or more)

f) R&T BASE CANDIDATE New Initiative candidate FY 78/

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Compared with silicon solar cells, gallium arsenide cells potentially may provide higher efficiency and higher radiation resistance while operating also at higher temperature. CVD will yield thin lightweight cells.

LEVEL OF STATE OF ART

1. LABORATORY ENVIRONMENT
2. THEORY TESTED IN LABORATORY ENVIRONMENT
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. FEASIBILITY OF FUNCTION CHARACTERISTICS DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN LABORATORY ENVIRONMENT
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Photovoltaic Conversion
High Temperature Solar Arrays

NO 10/P-2/PC-1
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

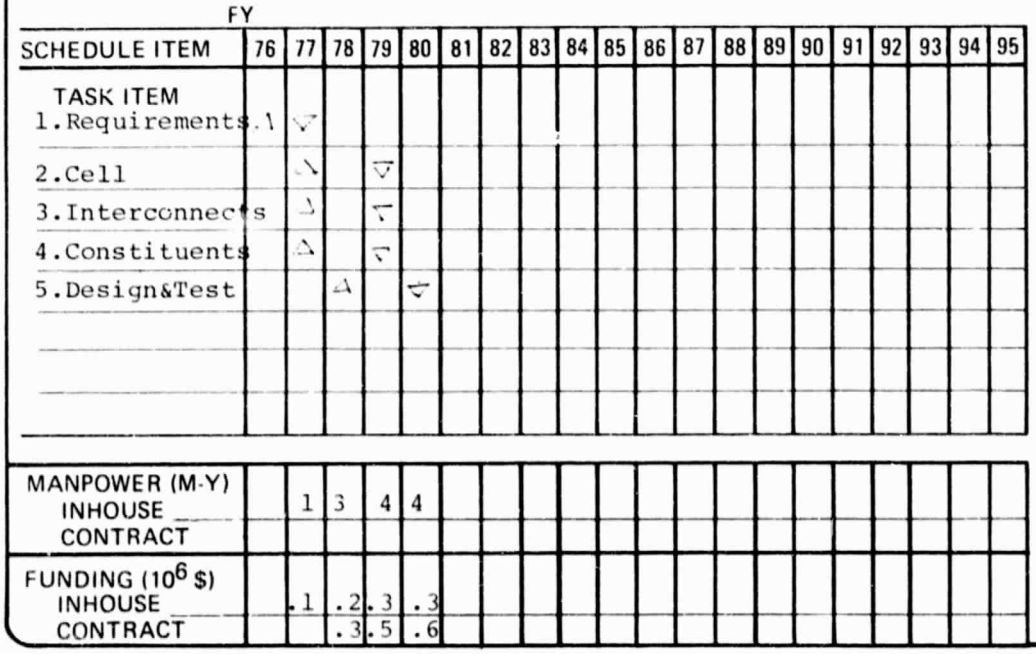
1. Identify specific requirements for mission such as Mercury orbit.
2. Develop space qualified solar cell.
3. Develop space qualified interconnect system.
4. Develop array constituents for high temperature system such as adhesives, encapsulants, and concentrators.
5. Develop integrated design.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-23-12

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE PHOTOVOLTAIC CONVERSION
SOLAR CELL CHARACTERIZATION

NO. 7,8,10,11/P-2 /PC-5
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE
To characterize the performance of solar cells over the range of temperature, illumination intensity and irradiation fluences experiences in a space enviornment.

3. NEED ANALYSIS

a) LEVEL NOW ☐, WILL BE LEVEL ☐ UNDER EXISTING PLANS. N/A

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY N/A
AT LEVEL ☐ FOR OPERATIONAL SYSTEM USE BY DATE: ☐

c) RISK IN ACHIEVING ADVANCEMENT: N/A
HIGH ☐ MEDIUM ☐ LOW ☐

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR
ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☐ ANALYSIS ☐ RESEARCH ☐
GRD TEST [X] AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE Yes: FY 76 506-23-12 $600

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

The technology exists to perform this task. It is the act of characterizing solar cells so that proper cells can be selected for specific solar system missions that is required. These characteristics are catalogued for use.

ORIGINAL PAGE IS
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LEVEL OF STATE OF ART
1. ENVIRONMENT OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 2 OF 2

TITLE Photovoltaic Conversion
Light-Weight, Low-Cost Silicon Arrays

NO. 7,8,10,11/P-2/PC-4
THEME / W.G. / TASK

DATE 4 /28 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

1. "Bolt-of-cloth" prototype machine analysis
2. Phase II design
3. Phase II "Bolt-of-cloth" demonstration
4. Establish feasibility of 200 w/kg array
5. Establish preliminary design
6. Develop and test prototype

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
1, See Plan	▽																			
2, See Plan		▽																		
3, See Plan			▽	▽																
4 See Plan					▽															
5, See Plan						▽														
6, See Plan							▽													
MANPOWER (M-Y)																				
INHOUSE	3	4	4	4	4	4														
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.1	.2	.2	.2	.2	.2														
CONTRACT	.2	.2	.2	.3	.3	.3														

SPACE TECHNOLOGY NEED — **FORM NO. 1**

PAGE 1 OF 2

1. TITLE PHOTOVOLTAIC CONVERSION
Light-Weight, Low-Cost Si Arrays

NO. 7, 8, 10, 11/P-2/PC-4
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE
Develop light-weight, low-cost solar arrays.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Technology Development (Check one or more)

f) R&T BASE CANDIDATE Yes: FY 76: 506-23-12 $320K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Design must be refined in order to develop a cell-to-blanket module assembly machine which will mechanically attach solar cells to a low-cost, light-weight substrate, electrically interconnect the cells and apply a radiation protection membrane over the finished solar cell. Present state-of-the-art rollout solar arrays are 66 w/kg. Studies have confirmed the feasibility of 100 w/kg arrays and indicate that 200 w/kg may be feasible. Methods of handling thin cells, flexible substrates and light-weight structures must be developed.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Photovoltaic Conversion Light Weight Radiation-Resistant Arrays

NO. 7,8,10/P-2/PC-2,
THEME / W.G. / TASK

DATE 4 / 28 / 76

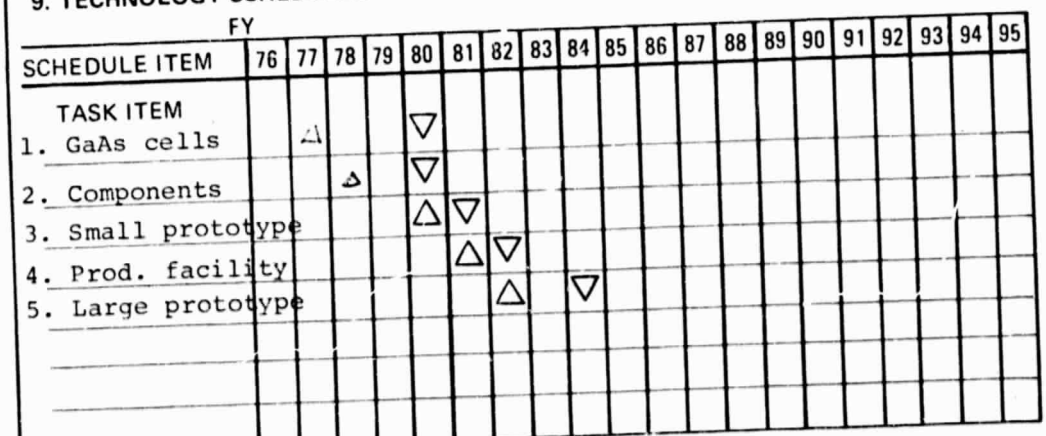
6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

1. Develop ultra-thin GaAs crystal technique and growth of large area solar cells.
2. Develop interconnect, encapsulation, and concentrator technique.
3. Test small prototype array eq 1 Kw
4. Develop automatic production facility for large arrays.
5. Produce prototype array

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)		2	5	7	8	8	8	8	8											
INHOUSE																				
CONTRACT																				
FUNDING (10^6 $)		.2	.4	.5	.6	.6	.6	.6	.6											
INHOUSE			.3	1.0	1.5	5.0	10	15	10											
CONTRACT																				

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Photovoltaic Conversion Technology for SEP and Payload Applications

NO. 1, 7-12/P-2 /PC-7
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

DESIGN, FABRICATE, AND DEMONSTRATE LARGE LIGHT WEIGHT SOLAR ARRAY 25 KWE, 30 WATTS/LB. 5-YEAR LIFE, RETRACTABLE, 400 V.

3. NEED ANALYSIS

a) LEVEL NOW [5], WILL BE LEVEL [6] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1979]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [X] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE YES (506-22-32 CURRENT PROGRAM) $50K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

POWER DISTRIBUTION, PROCESSING AND CONTROL.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

DEMONSTRATION OF MATERIALS AND ALTERNATES. SELECTION AND DEMONSTRATION OF INTER CONNECT BONDING. TECHNOLOGY FOR NON-DESTRUCTIVE TESTING (NDT) FOR POST-ASSEMBLY AND PREFLIGHT EVALUATION. OF PARTICULAR IMPORTANCE IS THE SOLAR CELL/SOLAR CELL INTER CONNECT BOND FOR THE WRAP-AROUND CONTACT CELL, USING NON-SOLDER METHODS. DEMONSTRATE TECHNOLOGY BY GROUND COMPONENT AND MODULE TEST AND ANALYSIS. ZERO "G" AIRCRAFT DEMONSTRATING DEPLOYMENT AND SHUTTLE FLIGHT EXPERIMENT OF SOLAR ARRAY.

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SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Photovoltaic Conversion
Solar Cell Characterization

NO. PC-5 7,8.10,11/P-2/
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Continuing program of evaluation of various types of solar cells to develop catalog of performance characteristics for application to any required space environment. Includes calibration of standard solar cells in space by balloon flight, aircraft, shuttle, or satellite.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY / SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
MANPOWER (M-Y) INHOUSE	4	5	5	5	5	→														
CONTRACT	2	2	2	2	2	→														
FUNDING (10^6 $) INHOUSE	.6	.6	.6	.6	.6	→														
CONTRACT	.2	.3	.3	.3	.3	→														

SPACE TECHNOLOGY NEED — **FORM NO. I**

PAGE 1 OF 2

1. TITLE Photovoltaic Conversion
Silicon Solar Cell Technology

NO. 1,7,8,9,11,12/P-2/PC-8
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE Develop technology for low cost ($5/w) solar cells and arrays with high end of life efficiency (14%)

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1985

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] Technology Development (Check one or more)

f) R&T BASE CANDIDATE Yes RTOP 506-23-17 $600K FY'76
Yes RTOP 506-23-12 $250K FY'76

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5 SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Development of cells with improved end of life efficiency. These may include some or all of epitaxially grown junction, ion implanted junction, back surface field, heavily doped base, wraparound contact and textured front surface. Definition of basic loss mechanism and radiation damage in photovoltaic devices. Investigation of processes for low cost fabrication; i.e., thick film processes and integration of automatable processes into fabrication line. New concepts for covering/encapsulating with plastic sheets. Newer cell concepts such as the multijunction edge illuminated silicon cell for use with concentrators.

LEVEL OF STATE OF ART

1 BASIC PHENOMENA OBSERVED AND REPORTED
2 THEORY FORMULATED TO DESCRIBE PHENOMENA
3 THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4 PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5 COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6 MODEL TESTED IN AIRCRAFT ENVIRONMENT
7 MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Photovoltaic Conversion Technology for SEP and Payload Applications

NO. 1.7-12/P-2/PC7
THEME / W.G. / TASK

DATE 4 / 28 / 76

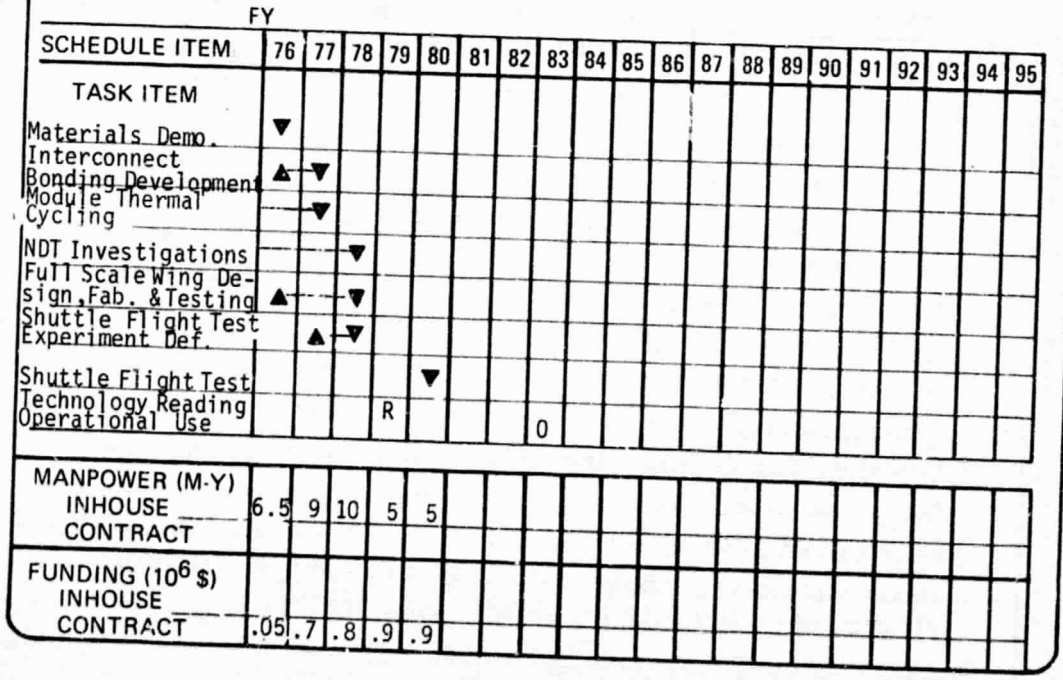
6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

This is an existing program. Preliminary design is complete, required technology has been identified and a representative section of a wing has been built and some testing performed. Materials investigations are underway. A non-destructive test technology program is proposed. It is proposed to demonstrate technology by ground component and module testing and analysis zero "G" aircraft deployment and Shuttle Flight Experiment

7. ALTERNATIVE APPROACHES/OPTIONS There is no real option to this solar array technology for the 1983 flight of the first MSPP with up to 100 KW power level.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

PAGE 1 OF 2

1. TITLE Energy Storage Technology for Improving Performance and Life of Alkaline Secondary Batteries

NO. 1,7,8,9,10/P-2/ES-1
THEME / W.G. / TASK

DATE 4 /26 / 76

2. OBJECTIVE To develop single cell protection devices, pulse charging techniques and separators to improve performance and life of alkaline secondary batteries.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1979]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

RTOP 506-16-12 $0 FY'76
RTOP 506-23-24 $100K FY'76
RTOP 506-23-23 $150K FY'76

f) R&T BASE CANDIDATE YES

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Single cell protection systems based on microelectronic circuits should significantly prolong the life of alkaline storage batteries. In cases where partially soluble electrodes are involved, i.e. Cd, Ag, Zn, pulse changing should help prevent textural changes on cycling and hence improve life. Inorganic-organic flexible separators have significant potential. Continuing work on these concepts for broader application to the Ni/Cd and Ag/H_2 systems are needed.

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 2 OF 2

TITLE Photovoltaic Conversion Silicon Solar Cell Technology

NO. 1,7,8, 9,11 P-2 PC8

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Continuing technology program aimed at improving the silicon solar cell. Various cell concepts are explored. The basic theory of radiation damage will define a new cell approach. Thinner cells and automated low cost fabrication techniques for low cost are defined.

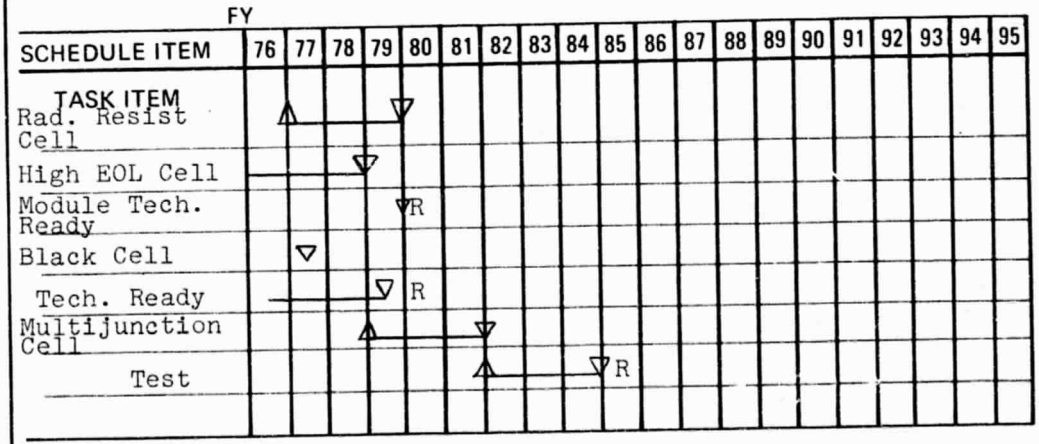
7. ALTERNATIVE APPROACHES/OPTIONS None

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-23-12

RTOP 506-23-17

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	13	12	12	15	3	3	3	3	3											
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.3	.27	.5	.5	.03	.03	.03	.03	.03											
CONTRACT	.5	.4	.95	1.0	.3	.3	.2	.2	.5											

'78 NEW INITIATIVE

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE Energy Storage
Silver Hydrogen Rechargeable Battery
Systems.

NO. 1,7,8,9,11/P-2/ES-2
THEME / W.G. / TASK

DATE 4 /26 / 76

2. OBJECTIVE To provide higher energy density, long life electrochemical energy storage system for synchronous orbit, 40 watt hr/#, 500 cycles, 10 yr. life.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1988]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] Technology Development (Check one or more)

f) R&T BASE CANDIDATE Yes RTOP 506-23-24, 190K FY '76

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Improved inorganic/organic battery separator, electrolyte reservoir plate.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

A higher energy density electrochemical storage capability is required. The A_g/H_2 system offers possible 40 watt hr/# synchronous orbit, 10 yr. life ~500 cycles. Based on a blending of inorganic-organic separator and battery electrode technology with electrolyte reservoir technology and hydrogen electrodes from fuel cell technology, this system represents an improvement over lightweight nickel cadmium.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Energy Storage Technology for Improving Performance and Life of Alkaline Secondary Batteries

NO. 1,7,8, 9,10 P-2 ES1
THEME / W.G. / TASK

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

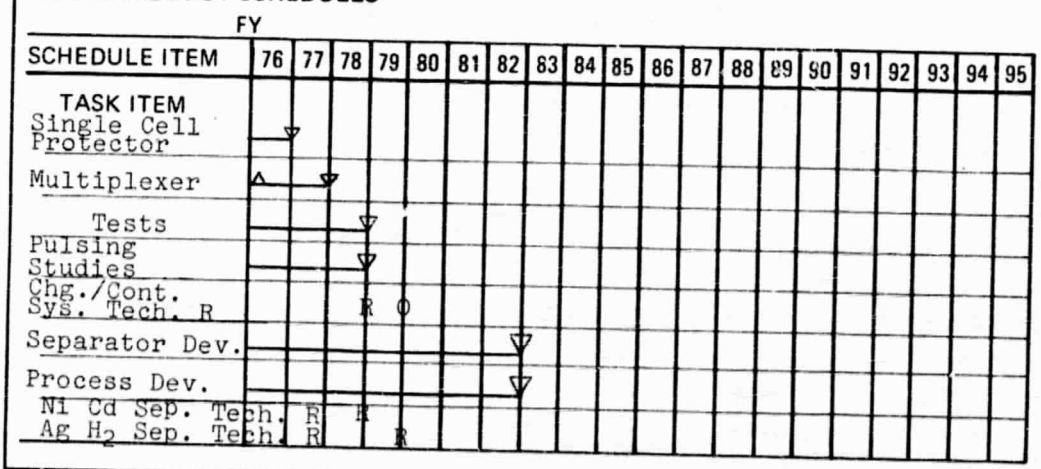
Electronic single cell protectors using microelectronics to be tested. Multiplexer concepts to be explored to reduce complexity. Pulse charging techniques to be studied to form basis for charger system design/development. Composite inorganic-organic materials to achieve flexibility, low cost and uniform material. Production methods will continue to evolve. Aimed at Ni/Cd and Ag/H_2 systems.

7. ALTERNATIVE APPROACHES/OPTIONS None; cell imbalance and life limiting processes lead to highly conservative operational use and thus the full capacities are not utilized.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-23-24
RTOP 506-23-23
RTOP 506-16-12

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	3.5	7	6	4	4	4	4													
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.13	.19	.1	.07	.07	.07	.07													
CONTRACT	.21	.25	.15	.1	.1	.1	.1													

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Energy Storage
Long-Life, Lightweight Ni-Cd Battery

NO. 1,7,8,10,11/p-2/ES-3
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE
Develop long life, lightweight (55 wh/kg) nickel-cadmium battery.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: [1983]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] technology development (Check one or more)

f) BRT BASE CANDIDATE Yes: FY 76, 506-23-24 - $50K
506-23-23 - $100K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Optimization of case, separator, and plaque design will result in upgrading the specific energy of Ni Cd cells.

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SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Energy Storage
Silver Hydrogen Rechargeable Battery Systems

NO. 1,7,8,9,10,11/P2/ES2
THEME / W.G. / TASK

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

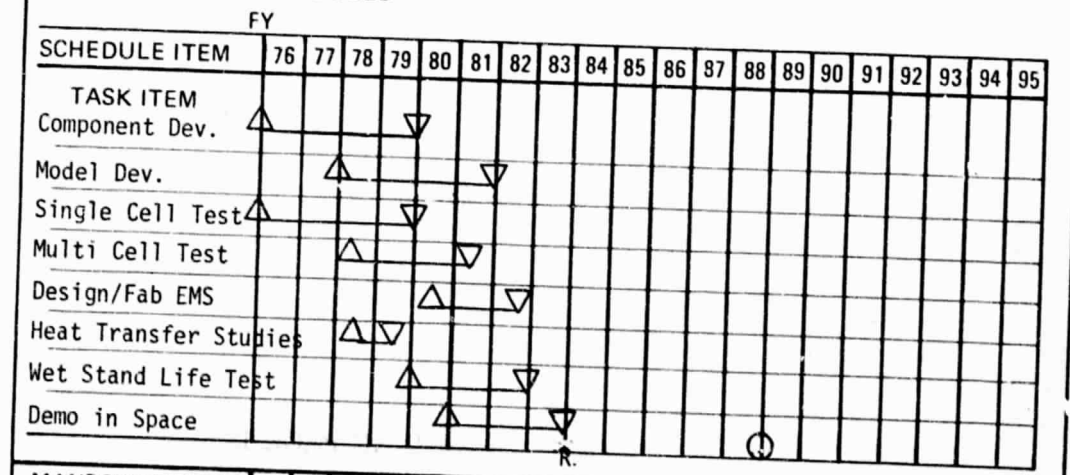
Cell components comprising inorganic/organic separators, electrolyte reservoir plates and electrodes, and pressure vessels will be developed for lightweight constructions. An engineering model system (EMS) will be developed for test and demonstration in space. Systems for synchronous orbit and probe missions will be developed.

7. ALTERNATIVE APPROACHES/OPTIONS The Ni/Cd battery, which even in its lightweight form will be twice as heavy. A regenerative hydrogen/oxygen fuel cell storage system represents an alternative (See EC 7,8)

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-23-24 covers supporting R&T work on this battery system. A 1978 New Start was submitted.

9. TECHNOLOGY SCHEDULES



MANPOWER (M-Y)																				
INHOUSE	1.	2	3	4	5	4	3	2												
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.12	.02	.04	.06	.06	.04	.04	.03												
CONTRACT	.07	.1	.65	1.6	1.4	.7	.6	0												

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Energy Storage

High Energy Density Batteries

NO. 1,7,8,9,11/P-2,'ES-4
THEME / W.G. / TASK

DATE 4 /26 /76

2. OBJECTIVE To provide rechargeable batteries for low earth orbit or synchronous orbit with energy densities > 100 watt hr/#.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] Technology Development (Check one or more)

f) R&T BASE CANDIDATE Yes RTOP 506-23-24 - 90K FY 76

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Thermal management of 300°C battery systems in space.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Rechargeable batteries based on alkali metals with solid electrolyte should be available from terrestrial programs operating ~300°C. These should be evaluated for large storage needs in space. Further research should provide similar energy density capabilities at ~100°C. Sodium as the negative and sulfur either molten or dissolved in organic solution or solid intercalation compounds with both ionic and electronic conduction, as the positives are likely choices.

LEVEL OF STATE OF ART
1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY ANALYTIC OR EXPERIMENTAL PROOF OF CONCEPT
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN LABORATORY ENVIRONMENT
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Energy Storage
Long-Life, Lightweight Ni Cd Battery

NO. 7,8,10,11/P-2/ES-3
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Fourteen step process addressing lightweight cases, seals, and plaques and optimizing separator design.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Electrode Stud	△		▽																	
Plaque Design		△	▽																	
Case Design	△	▽																		
Battery Design		△			▽															
MANPOWER (M-Y) INHOUSE	1	1	1	1	1															
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.1	.1	.1	.1	.1															
CONTRACT	.1	.1	.1	.1	.1															

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE ENERGY STORAGE
PRIMARY PROBE BATTERIES

NO. 10/P-2 / ES-5
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

DEVELOP BATTERIES FOR PROBES WHICH CAN DELIVER HIGH POWER OUTPUT AFTER PROLONGED (7-10 YEARS) STORAGE.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1983]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] TECHNOLOGY DEVELOPMENT (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

REMOTELY ACTIVATED BATTERIES HAVING AN ENERGY DENSITY OF 40 WH/LB ARE DESIRED FOR PROBE APPLICATIONS. PRESENT ENERGY DENSITIES OF 8 SH/LB ARE AVAILABLE. ACTIVATION DEVICES, SEPARATORS, AND CHEMICAL SYSTEMS OTHER THAN AG ZN WILL BE EXAMINED.

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SPACE TECHNOLOGY NEED FORM NO. I

PAGE 2 OF 2

TITLE Energy Storage
High Energy Density Batteries

NO. 1,7,8, 9,11 P-2 ES4
THEME / W.G. / TASK

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

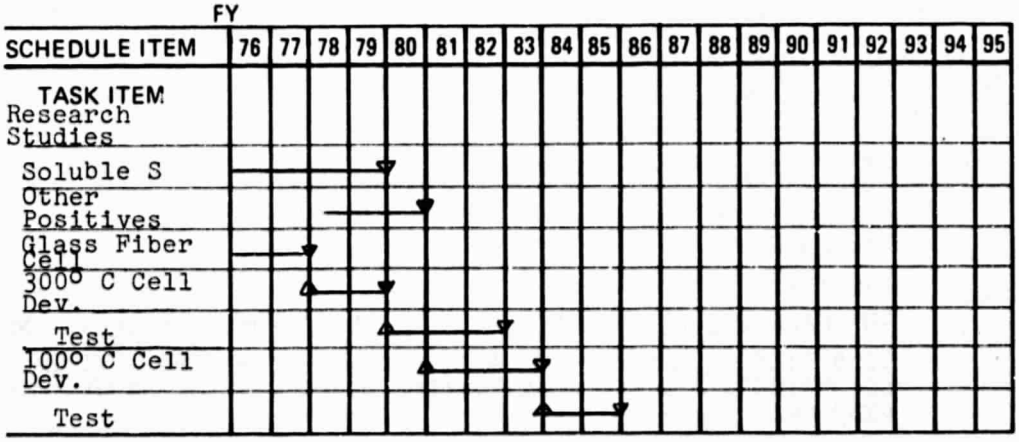
Ongoing technology programs for terrestrial energy storage is developing several 300 °C > 100 watt hr per # batteries. The most promising versions will be selected and modified to meet space requirements and tested. Continued research on systems operating ≤ 100 °C will be carried out.

7. ALTERNATIVE APPROACHES/OPTIONS None, except tradeoff depending on storage capacity requirement against regenerative fuel cell systems.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-23-24, and ERDA programs in high energy batteries.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	2	2.5	2.5	3	3	3	3	2	1	1										
CONTRACT																				
FUNDING (10^6 $) INHOUSE	0	.02	.02	.02	.02	.02	.02	.02	.02	.02										
CONTRACT	0	.05	.2	.2	.1	.2	.2	.2	.1	.1										

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OF POOR QUALITY

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Energy Storage
Large Ni Cd Batteries

NO. 7,8 / P-2 /ES-6
THEME / W.G. / TASK

DATE 4 /27 / 76

2. OBJECTIVE
Develop a 100 Ah NiCd battery having five year cycle life.

3. NEED ANALYSIS

a) LEVEL NOW [5], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR
ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Technology development (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Technology development to flight ready status is required for a large (100 Ah) cell and battery for energy storage for the MSPP. The problem is one of scale-up, and optimization of performance by using the most appropriate electrode plaques, separators, and cases. Particular attention needs to be directed to thermal control problems

LEVEL OF STATE OF ART

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Energy Storage
Primary Prote Batteries

NO. 10/ P-2/ES-5
THEME / W.G. / TASK

DATE 4 / 28 / 76

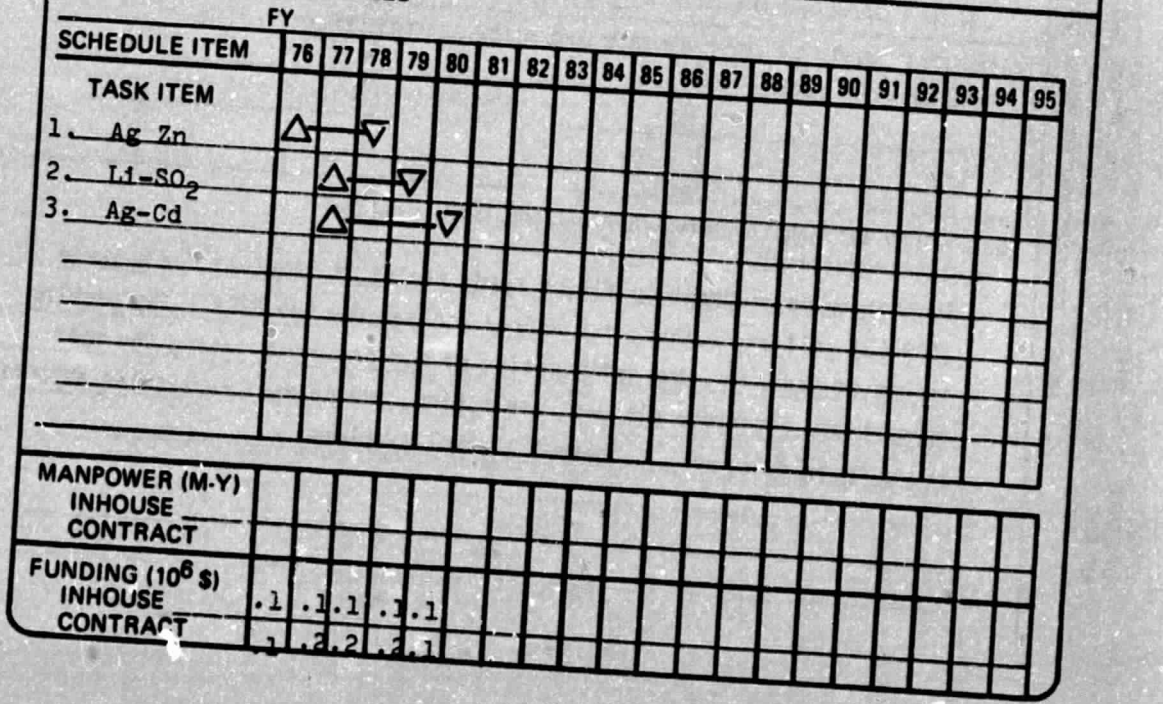
6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

1. Remotely activated Ag -Zn
2. Remotely activiated Li-SO_2 and Li-H_2O
3. Rechargeable Ag-Cd

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE Energy Storage
Advanced Regenerative Hydrogen/
Oxygen Fuel Cell Systems

NO. 1,7,8,9,11/P-2/ES7
THEME / W.G. / TASK

DATE 4 /26 /76

2. OBJECTIVE Second Generation Fuel Cell Technology for Regenerative H_2/O_2 Energy Storage

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [ ] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1991

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Technology Development (Check one or more)

f) R&T BASE CANDIDATE YES - NEW INITIATIVE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Second generation fuel cell development

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

The regenerative H_2/O_2 electrolyzer/fuel cell for energy storage can be further improved beyond the lightweight technology fuel cell by utilizing the higher efficiency higher power density components. The electrolyzer will need to be optimized for use with the second generation fuel cell and the system integrated for storage application.

ORIGINAL PAGE IS
OF POOR QUALITY

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE
Energy Storage
Large Ni Cd Batteries

NO. 7, 8 /P-2/ES 6
THEME / W.G. / TASK

DATE 4 /28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

1. Establish environmental and performance requirements
2. Develop specifications
3. Procure protypes
4. Test in ground environment

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
1. Reqts.			▽																	
2. Spec.			▽																	
3. Prototype			△	▽																
4. Gnd.Qual.				△	▽															
MANPOWER (M-Y) INHOUSE			1	2	2															
CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
CONTRACT			25	05	0.5															

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OF POOR QUALITY

SPACE TECHNOLOGY NEED

1. TITLE ENERGY STORAGE PHOTOVOLTAIC - ELECTROLYSIS - FUEL CELL POWER SYSTEM

NO. 1,7,8,9,&11/P-2/ES-8
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

ESTABLISH AN OPERATIONAL BREADBOARD USING AVAILABLE TECHNOLOGY FOR DISCRETE PORTIONS OF THE SYSTEM.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1984]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] DEMONSTRATION OF SYSTEM (Check one or more)

f) R&T BASE CANDIDATE YES

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

LIGHT WEIGHT FUEL CELL HIGH POWER, LIGHT WEIGHT SOLAR ARRAY.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

THIS CONCEPT USES SOME FORM OF PHOTOVOLTAIC CONVERSION TO PROVIDE ELECTRICAL ENERGY DURING THE SUNLIGHT PORTION OF THE ORBIT. EXCESS ENERGY IS STORED IN THE FORM OF HYDROGEN AND OXYGEN GASES GENERATED BY A WATER ELECTROLYSIS UNIT. DURING THE ORBITAL NIGHT THE HYDROGEN AND OXYGEN ARE CONVERTED TO ELECTRICAL ENERGY AND WATER BY THE FUEL CELL. THIS CONCEPT USES THE PRINCIPLE OF A REGENERATIVE FUEL CELL WITH DEDICATED ELECTROLYSIS AND FUEL CELL STACKS TO ELIMINATE PROBLEMS AND ENABLE ADAPTABILITY TO LARGE POWER SYSTEMS.

SPACE TECHNOLOGY NEED FORM NO. I

TITLE Energy Storage
Advanced Regenerative Hydrogen/
Oxygen Fuel Cell Systems

NO. 1,7,8,9,11/P2/ES7
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

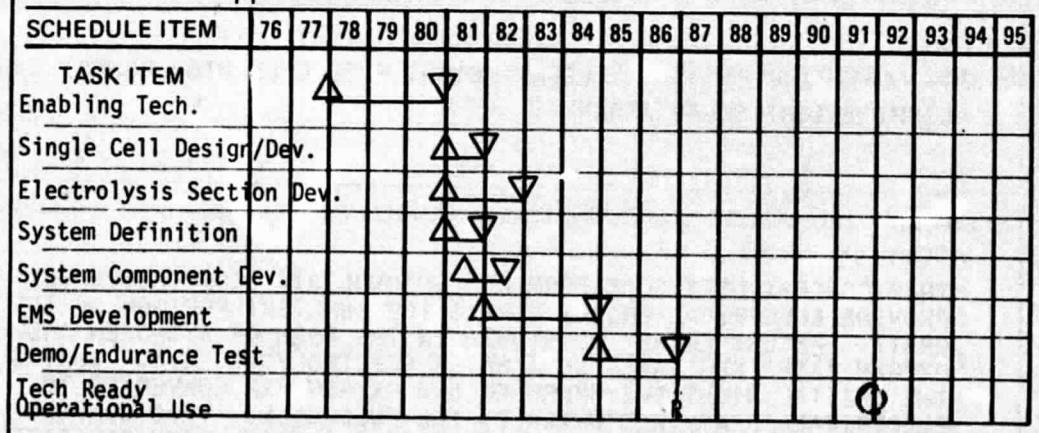
The second generation fuel cell technology (ECC-2) will be paralleled in an electrolysis system and the systems developed for modular application for large energy storage applications. Lightweight, high efficiency, high current density in the alkaline system.

7. ALTERNATIVE APPROACHES/OPTIONS The ion exchange membrane type fuel cell/electrolysis system and the first generation lightweight alkaline systems. These have 1/2 the specific power. High energy density batteries may be applicable.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 909-44-05-54 on the ion exchange membrane version of the system, 910/ RTOP 506-23-24 and New Start on the second generation advanced fuel cell.

9. TECHNOLOGY SCHEDULES



MANPOWER (M-Y)																					
INHOUSE			1.5	1.5	1.5	2	2.5	3	1	.5	.5										
CONTRACT																					
FUNDING (10^6 $)																					
INHOUSE			.02	.02	.02	.05	.05	.05	.05	.01	0										
CONTRACT			.2	.2	.2	2.5	2.0	1.5	1.0	.5	.5										

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE ELECTROCHEMICAL CONVERSION LIGHT-WEIGHT FUEL CELL

NO. 1,7,8,12 / P-2/ECC-1
THEME / W.G. / TASK

DATE 4 /26/76

2. OBJECTIVE
Design, fabricate, test and demonstrate a light-weight fuel cell power plant to operate on propellant grade reactants.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1980]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [x]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [x] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [x] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes 506-23-24 100K
910-05-03 125K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
This continuing task is directed towards design, fabrication, testing and demonstration of a light-weight fuel cell power plant technology capable of operating from reactants acquired from the vehicle propulsion tanks, which eliminates the need for dedicated tankage and reactants. The basic design will be available in modular sizing from 3 to 24 KW at a 15 lb/kw power density and 5,000 hr. life. The design will be based on a single-cell design developed by LeRC.

LEVEL OF STATE OF ART
1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

ORIGINAL PAGE IS OF POOR QUALITY

SPACE TECHNOLOGY NEED — **FORM NO. I**

TITLE ENERGY STORAGE
PHOTOVOLTAIC - ELECTROLYSIS
FUEL CELL POWER SYSTEM

NO 1,7,8,9,11/P-2/E58
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

The approach is to utilize existing technology to build an operational breadboard to evaluate the regenerative fuel cell concept for energy storage using dedicated fuel cells and electrolysis units. Breadboard will be used to establish parametric performance characteristics and to establish system interface requirements.

7. ALTERNATIVE APPROACHES/OPTIONS The alternate is to use the Ni/Cd batteries which become extremely heavy at the high power levels or develop much higher energy density batteries.

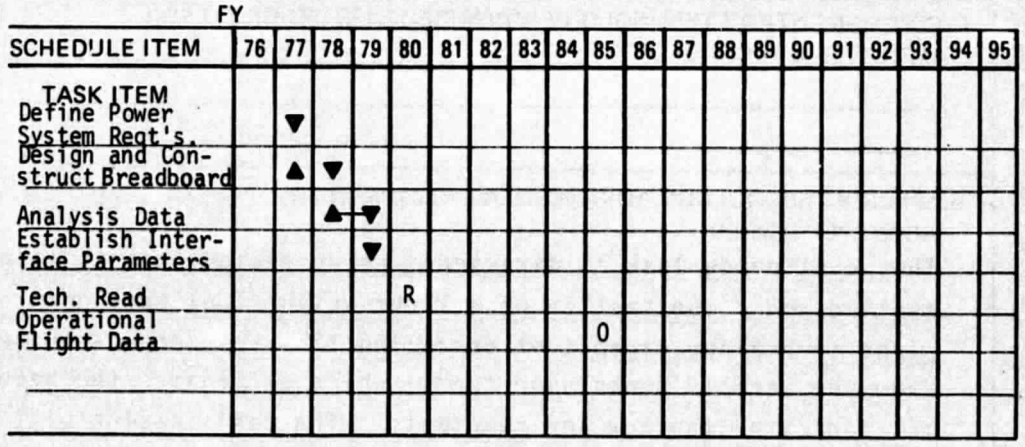
8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 910-44-05 Ion Exchange Membrane Fuel Cell at JSC.

RTOP 910-05-03 Lightweight Fuel Cell at MSFC.

RTOP 506-23-24 Fuel Cell at LeRC

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 3

1. TITLE Electrochemical Conversion - Second Generation Fuel Cell Technology (Alkaline Matrix and Ion Exchange Membrane Acid)

NO. 1,7,8,9,11,12/P-2/ECC2
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE Develop alkaline H_2/O_2 lightweight second generation fuel cell, .9 V, > 3000 hrs, 250°F and develop an acid IEM fuel cell with 100,000 hr life and invariant performance.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1988

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [X] Technology Development (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY High temperature oxidation resistant polymeric materials for matrices and construction. Catalysts and electrode reactions technology.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

1) A solid polymer IEM acid fuel cell stack has run over 35,000 hours with no detectable performance degradation, 100,000 hours at higher efficiencies are reasonable goals with higher pressure operation.

2) By replacing asbestos as a matrix material with fibrous polybenzimadazole or other polymer mat., an improved catalyst and heat removal system, higher operating temps can be utilized. This yields higher efficiencies at lower weights.

3) Both these systems are a necessary part of the advanced fuel cell/electrolysis (regen fuel cell) energy storage system.

4) One Page 2 for each of these concepts.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

TITLE Electrochemical Conversion
Second Generation Fuel Cell Technology

ECC2
NO. 1,7,8,9,11,12/P-2/
THEME / W.G. / TASK

DATE 4 /28 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

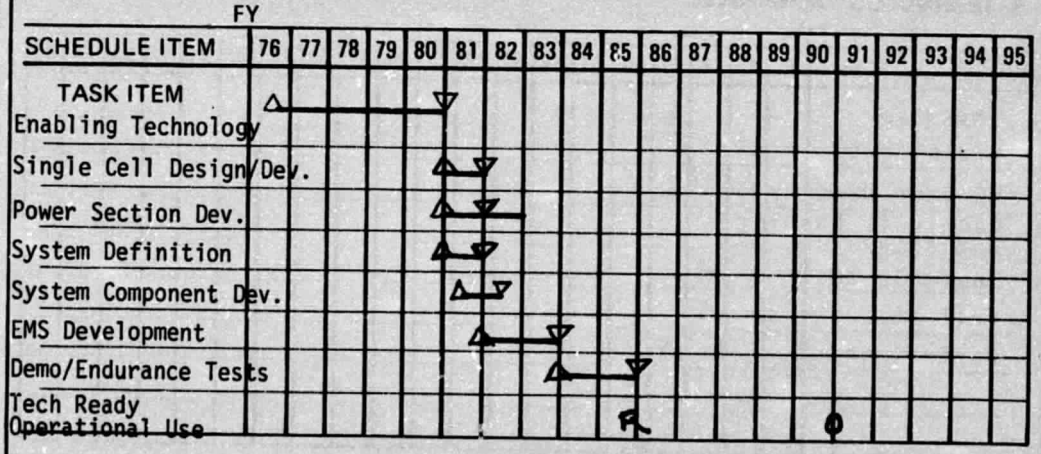
Develop new materials of construction, electrocatalysts, materials and heat removal systems and incorporate in lightweight designs. Evaluate a single cell design to prove out concept then develop and test an Engineering Model System (EMS) for system demonstration and endurance test on the ground. This is alkaline technology.

7. ALTERNATIVE APPROACHES/OPTIONS The other option is the first generation lightweight technology operating at much lower current density with proportionately for poorer power density.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Work on polybenzimadazole fibers for matrices underway in FY 76, R&T work on single cells, plaques to start FY 77, all under RTOP 506-23-24. New Start 1981 submitted.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	.5	1.5	1.5	1.5	2	2	2.5	3	.5	.5										
CONTRACT	-	-	-	-	-	-	-	-	-	-										
FUNDING (10^6 $)																				
INHOUSE	.0	0	.02	.02	.03	.05	.05	.01	.01	0										
CONTRACT	.05	.2	.2	.2	.2	2.8	2.0	1.2	.5	.5										

SPACE TECHNOLOGY NEED — **FORM NO. 1**
PAGE 3 OF 3

TITLE Electrochemical Conversion
Ion-Exchange Membrane Fuel Cell Technology

NO. 1,7,8,9,11/P-2/ECC-2
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Continue current program with primary effort on sub-scale hardware. Scale up to full-size cells at appropriate time. The program will not go to full system tests but will solve technology problems in stack testing which will allow the concept to be designed into a system after the program or application is defined.

7. ALTERNATIVE APPROACHES/OPTIONS None

Fy 76 RTOP 909-44-05-54

FY 77 RTOP 910-44-05-54

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Matls tests		Δ																		
Hi-Curr Density		Δ																		
Catalysts Loading and alloys		Δ																		
Subscale tests			Δ																	
Full size cells			Δ																	
Partial stacks				Δ																
MANPOWER (M-Y) INHOUSE CS		.3	.5	.7																
CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
CONTRACT	.125	.14	.20	.28																

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE ELECTROCHEMICAL CONVERSION FUEL CELL ELECTRODE AND CATALYTIC TECHNOLOGY

NO. 1,7,8,9,11/P-2/ECC-3
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Evaluate fuel cell electrode reactions and catalysts efficiencies to enhance performance.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [4] UNDER EXISTING PLANS

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1980]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X] GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Using the technique of ESCA (Electron Spectroscopy for Chemical Analysis) research will be performed to further understanding of fuel cell chemical phenomena such as surface reactions, catalytic processes, and electrodes. This technology will aid in the search for cheaper catalysis.

LEVEL OF STATE OF ART

1 BASIC PHENOMENA OBSERVED AND REPORTED
2 THEORY FORMULATED TO DESCRIBE PHENOMENA
3 THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4 PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5 COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6 MODEL TESTED IN AIRCRAFT ENVIRONMENT
7 MODEL TESTED IN SPACE ENVIRONMENT

ORIGINAL PAGE IS OF POOR QUALITY

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 2 OF 2

TITLE ELECTROCHEMICAL CONVERSION-
FUEL CELL ELECTRODE & CATALYTIC TECHNOLOGY

NO. 1,7,8,9,11/P-2/ECC-3
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

The initial phase will investigate known catalysts to determine characteristics. The second phase will search for naturally occurring materials which have catalytic properties. The third phase will synthesize materials in search for inexpensive catalysts.

7. ALTERNATIVE APPROACHES/OPTIONS Continue to use expensive platinum or gold.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Exam. Cat.		—	—	Δ																
Exam. Naturally Occurring Materials			—	—	Δ															
Synthesis of Materials				—	—	Δ														

MANPOWER (M-Y) INHOUSE	.25	.25	.25	.25	.25	.25														
CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
CONTRACT		.035	.046	.049	.050	.050														

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE POWER PROCESSING DISTRIBUTION AND CONTROLS: ADVANCED ELECTRONIC POWER CONDITIONING TECHNOLOGY

NO. 1,7-12/P-2/PP-1
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

DEVELOP TO TECHNOLOGY READY STATUS UNIQUE HARDWARE ITEMS REQUIRED TO ENABLE ADVANCED HIGH POWER ELECTRICAL POWER SYSTEM CONCEPT IMPLEMENTATION.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE:]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] HARDWARE DEMONSTRATIONS (Check one or more)

f) REF BASE CANDIDATE: YES (506-23-30) ($450K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

HIGH VOLTAGE MATERIALS TECHNOLOGY, HIGH POWER/HIGH VOLTAGE/LOW LOSS ELECTRONIC COMPONENT DEVELOPMENT.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

TECHNOLOGY ADVANCEMENT IN HIGH POWER ADVANCED ELECTRICAL POWER CONDITIONING IS REQUIRED BECAUSE OF THE SEVERE IMPACT PRESENT TECHNOLOGY HAS ON SUCH KEY PARAMETERS AS WEIGHT, EFFICIENCY AND RELIABILITY. SPECIFICALLY, ADVANCED ELECTRICAL POWER CIRCUIT TECHNOLOGY IS REQUIRED FOR SUCH AREAS AS ELECTRICAL CONDITIONING FOR THERMIONIC CONVERTERS (I.E., HIGH CURRENT, LOW VOLTAGE), BI-DIRECTIONAL FOUR QUADRANT POWER CONDITIONERS FOR BATTERY CHARGE-DISCHARGE CYCLES, AND HIGH VOLTAGE, HIGH POWER CONDITIONERS FOR RF TRANSMISSION.

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE POWER PROCESSING DISTRIBUTION AND CONTROL: ADVANCED ELECTRONIC POWER CONDITIONING TECHNOLOGY

NO. 1, 7-12/P-2/PP-1
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(1) Identify unique Power Conditioning needs which constitute major mission penalties and/or impediments.

(2) Evolve and implement a technology ready program addressing solutions to unique power conditioning requirements of (1) above.

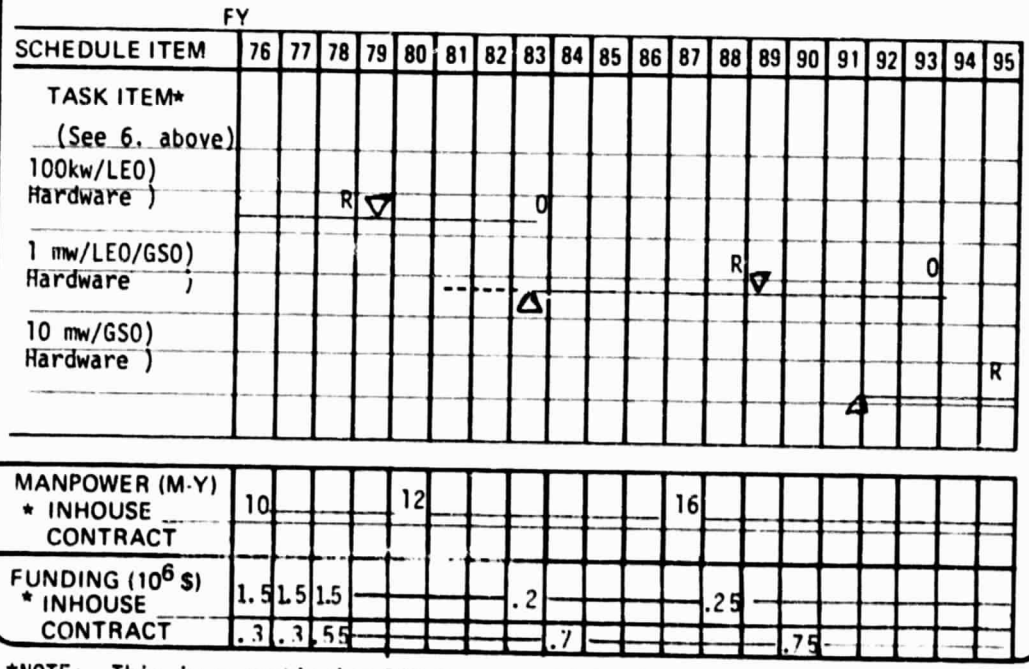
(3) Verify adequacy of approach (weight, efficiency, etc.) and availability of power circuit sub-element designs.

7. ALTERNATIVE APPROACHES/OPTIONS Wait until project phase C/D to begin design and incur the historical problem of cost overruns due to technical roadblocks and schedule slips associated with power conditioning hardware.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Power Processing and Distribution Technology
506-23-30

9. TECHNOLOGY SCHEDULES



*NOTE: This is a continuing R&T Program which addresses varying user needs; data shown is average level of effort.

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Power Processing Distribution and Control: Integrally Regulated Solar Array Technology

NO. 1-7-8-9-10-11/P-2/PP-2
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE DEVELOP TO TECHNOLOGY-READY STATUS, THE APPLICABILITY OF DIRECT ON THE ARRAY REGULATION OF ELECTRICAL POWER FOR DEDICATED LOADS.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [6] FOR OPERATIONAL SYSTEM USE BY [DATE:]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [ ] RESEARCH [X]
GND TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) BOT BASE CANDIDATE YES (506-23-30) ($150K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY HIGH VOLTAGE MATERIALS TECHNOLOGY
SPACE ENVIRONMENTAL INTERACTIONS

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

NO MAJOR ELECTRICAL ENGINEERING TECHNOLOGY ADVANCEMENT IS REQUIRED; HOWEVER, TWO OTHER AREAS DO REQUIRE TECHNOLOGY ADVANCEMENT. SPECIFICALLY, THE SPACE ENVIRONMENTAL INTERACTION EFFECTS OF PLASMA/CHARGING FOR LARGE HIGH VOLTAGE SYSTEMS AND THE PROPER APPLICATION OF HIGH VOLTAGE MATERIALS.

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OF POOR QUALITY

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE POWER PROCESSING DISTRIBUTION AND CONTROL:
INTEGRALLY REGULATED SOLAR ARRAY TECHNOLOGY

NO. 1.7-12/P-2/PP-2
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

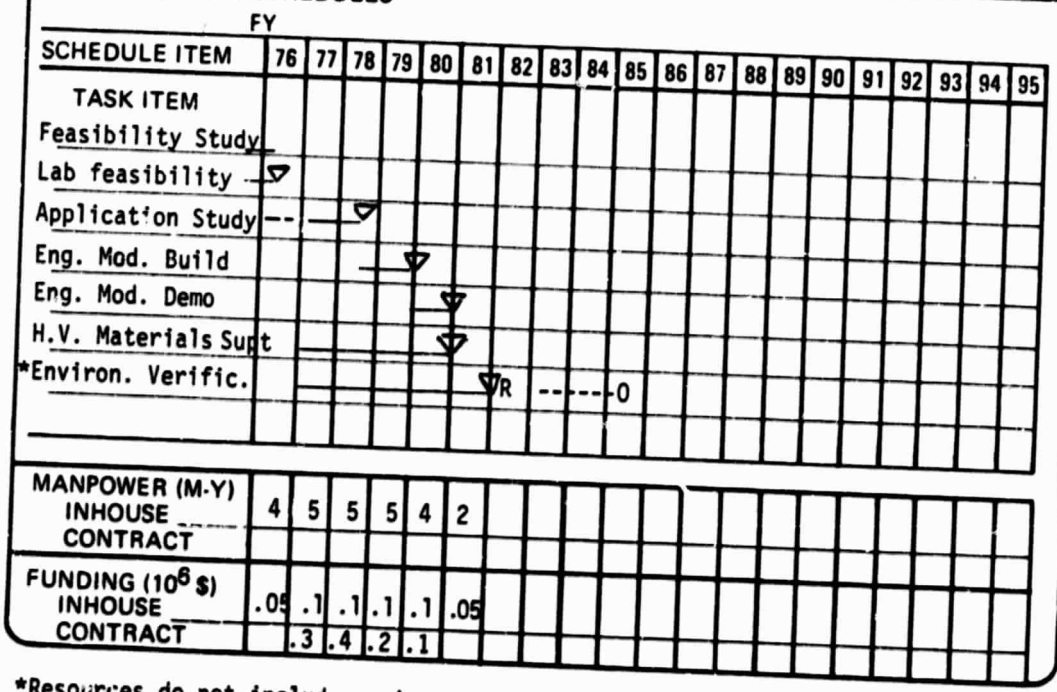
(1) Feasibility Study (completed)
(2) Laboratory feasibility demonstration (completed)
(3) Application study
(4) Engineering model demonstration
(5) Environmental interaction compatibility verification (see power sectopm P-2 EI1 through EI5)

7. ALTERNATIVE APPROACHES/OPTIONS Use previous approach of unregulated solar array with in-line voltage regulation and load power conditioning and accept the weight and efficiency penalties.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Existing program at LeRC
Power Processing and Distribution Technology
506-23-30

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	4	5	5	5	4	2														
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.05	.1	.1	.1	.1	.05														
CONTRACT		.3	.4	.2	.1															

*Resources do not include environmental program data.

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE POWER PROCESSING, DISTRIBUTION AND CONTROL: HIGH POWER/HIGH VOLTAGE/LOW LOSS ELECTRONIC COMPONENT DEVELOPMENT

NO. 1,7,8,9,10, 11,12/P-2/PP-3 THEME / W.G. / TASK

DATE 4 / 20 76

2. OBJECTIVE

Develop to a technology ready status identified electronic components (i.e., rectifiers, power transistors, capacitors, power magnetics, etc.) presently limiting advanced power system concepts.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE:]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Demonstrate with Prototype (Check one or more)

f) R&T BASE CANDIDATE Yes (506-23-31) ($450K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

None other than basic solid state physics and high voltage materials technology.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

As power levels increase to 10's and 100's of kilowatts, (even more in some cases), hardware inefficiencies (component electrical losses) become increasing important. Two technology advances are therefore required in the general area of power electronic components (1) increase the efficiency, and (2) increase the power (current and voltage) handling capabilities of specific components identified as limiting or penalizing advanced electrical power system concepts.

LEVEL OF STATE OF THE ART

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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OF POOR QUALITY

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE POWER PROCESSING, DISTRIBUTION AND CONTROL: HIGH POWER/HIGH VOLTAGE/LOW LOSS ELECTRONIC COMPONENT DEVELOPMENT

NO. 1,7-12/P-2/PP-3
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(1) Identify new unique power component needs which constitute major mission penalties and/or impediments.

(2) Evolve and implement a technology development program addressing solutions to new and unique power component requirements of (1) above.

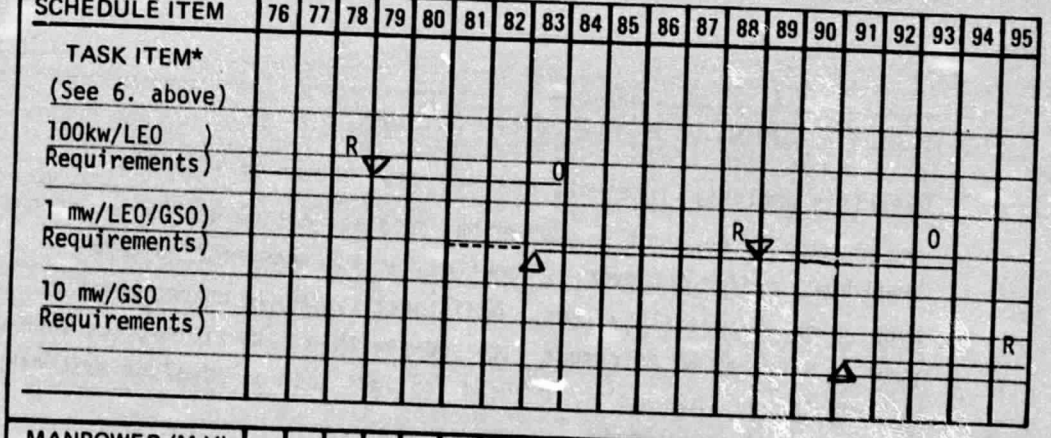
(3) Verify performance characteristics and, if practical, incorporate developed device in user test program.

7. ALTERNATIVE APPROACHES/OPTIONS For high power high voltage power electronic designs availability of components (solid state and static) are limiting factors.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

High Performance Power Electronic Components
506-23-31

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) *INHOUSE	4	6				8									10					
CONTRACT																				
FUNDING (10^6 $) * INHOUSE	.15	.2				.24									.28					
CONTRACT	.3	.4				.6				.8										

*NOTE: This is a continuing R&T Program which addresses varying user needs; data shown is average level of effort.

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Power Processing, Distribution and Control; High Voltage Materials Technology

NO. 1, 7, 8, 9, 10, 11, 12/p-2/PP-4
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE
Provide a firm materials technology base for advanced high-power/high-voltage electrical power system concepts (that is, dielectric films, encapsulents, conformal coatings, etc.)

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE:]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Laboratory testing (Check one or more)

f) R&T BASE CANDIDATE Yes (506-23-30) ($30K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Materials analysis, research, and characterization of life limiting and physically destructive mechanisms such as partial discharge, corona breakdown, and/or arc over is required for advanced high-voltage high-power electrical systems. Additionally, unique characteristics such as material photoconductivity and new thin film dielectrics such as polyvinylidene fluoride or advanced coatings such as paralyne must be exploited and understood.

LEVEL OF STATE OF ART
1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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SPACE TECHNOLOGY NEED

FORM NO. I

TITLE POWER PROCESSING, DISTRIBUTION, AND CONTROL: HIGH VOLTAGE MATERIALS TECHNOLOGY

NO. 1,7-12/P-2/PP-4
THEME / W.G. / TASK

DATE 4 /27 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Past programs which contained high voltage power electronic hardware (SERT, SPHINX, GEOS, CTS, etc) have consistently encountered technical problems (some serious) in the area of high voltage electrical phenomenon (corona & arcing). In order to confidently pursue multi-hundred kilowatt power programs, a firm technology base in high voltage materials is essential.

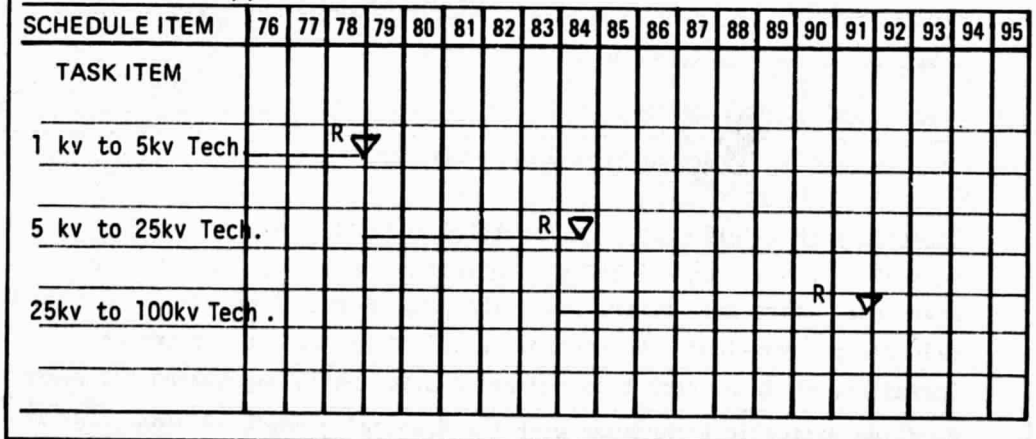
7. ALTERNATIVE APPROACHES/OPTIONS

Solve technical problems as they develop and accept a very high risk approach ($ overrun/schedule slips)

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

A small effort now is included in Power Processing and Distribution RTOP 506-23-30

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	1	2		3						4										
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.03	.1					.2				.3									
CONTRACT		.2		.3						.4										

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Power Processing, Distribution and Control: Remote Power Controller (RPC) Technology for High Power dc Distribution Systems

NO. 1, 7, 8, 10, 11/p-2/PP-5
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE Provide technology ready development base for RPC's in the range of 10's to 100's of amperes and 100's to 1000's of volt dc (that is, solid-state switch gear)

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE:]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [ ] RESEARCH [ ] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [X] devel. & demo. via protoflight (Check one or more)

f) R&T BASE CANDIDATE Yes (506-23-31) ($50K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY high-power high-voltage solid-state switches (that is, transistors and/or silicon controlled rectifiers)

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Starting with existing 28 volt (Shuttle) and 120 volt (Lewis R.C. technology ready program) RPC R&D activities, a gradual growth of RPC power capacities will be evolved. The program evolution will specifically maintain present logic and control capabilities such as i^2t and/or instantaneous 3x current trip characteristics while augmenting the power handling rating in accordance with the developing needs of high power dc electrical distribution sytems.

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE POWER PROCESSING, DISTRIBUTION, AND CONTROL: REMOTE POWER CONTROLLER (RPC) TECHNOLOGY FOR HIGH POWER dc DISTRIBUTION SYSTEMS

NO. 1,7-12/P-2/PP-5
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

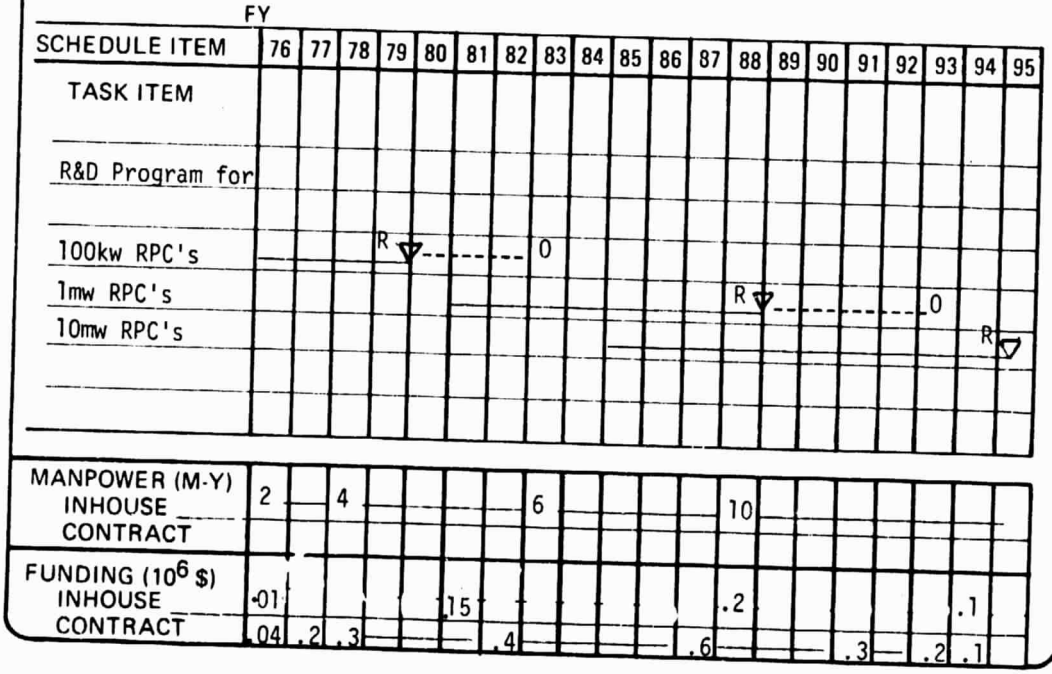
Using the existing technology demonstration program (LeRC) for 120 vdc RPC's as a model, similar programs will be evolved for a family of load RPC's in the range of 120 vdc/30a to 480 vdc/100a, and for a family of bus RPC's in the range of 1 kvdc/50a to 30 kvdc/150 a. Three power systems levels will be addressed, 100 kilowatts, 1 megawatt, and 10 megawatts.

7. ALTERNATIVE APPROACHES/OPTIONS Without the availability of properly sized RPC's, proposed advanced electrical power systems cannot be designed.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Present work is limited to 270 vdc as an upper limit -RTOP 506-23-30 Power Processing and Distribution Technology.

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Power Processing, Distr., and Cont.; Long LIfe, High Performance Power Processing for Planetary Applications

NO. 7,7,8, 10,11 P-2/PP-6
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

Develop and demonstrate advanced power processing and distribution technology for future planetary programs to achieve 10 year lifetimes, high efficiency, reliability and transient and failure immunity.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1982]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [XX] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Development (Check one or more)

f) R&T BASE CANDIDATE Yes; RTOP 506-23-33; FY'76; $435K;to be expanded

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

0 Develops modular, active redundant regulators and inverters for operation with solar arrays and RTGS.

0 Develops battery charge electronics to regulate charge and discharge, and monitor, control, and protect spacecraft batteries for long-life planetary missions.

0 Develops new design and analysis techniques at the component, circuit, and system levels.

0 Modular designs allow for power growth, processing of high power quantities, and scaling to a wide variety of voltage levels for 100 KW applications and nuclear power systems processors.

LEVEL OF STATE OF ART

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PERFORMANCE
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE POWER PROCESSING, DISTRIBUTION, AND CONTROL; LONG LIFE, HIGH PERFORMANCE POWER PROCESSING FOR PLANETARY APPLICATIONS

NO. 1,10/P-2/PP-6
THEME / W.G. / TASK

DATE 4 / 29 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- o Techniques and hardware to reliably and efficiently provide uninterrupted power to science and housekeeping loads from S/A and RTG sources are in development - up to several KW at up to several hundred volts
- o Battery system electronics development for extended life was started
- o Modular PPE concepts to be expanded to accommodate: (1) reactor sources; (2) high radiation and temperature environments; (3) 10-20 years life; (4) SEP and NEP compatible loads.

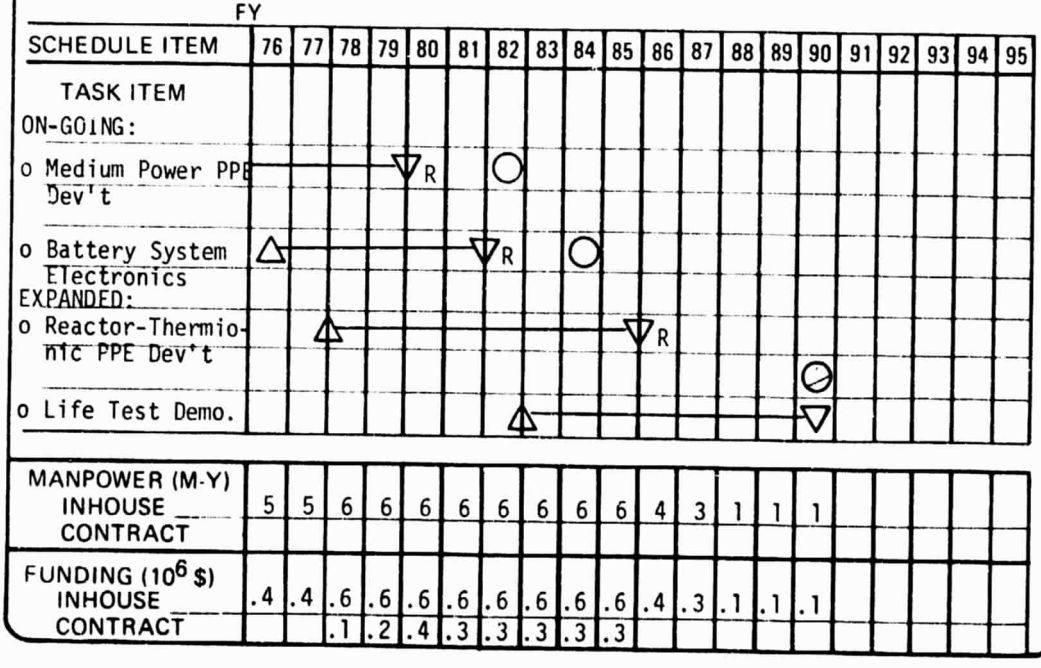
7. ALTERNATIVE APPROACHES/OPTIONS

No reasonable alternatives.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-23-33 provides the baseline program. On-going and expanded efforts are indicated below.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	5	5	6	6	6	6	6	6	6	6	4	3	1	1	1					
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.4	.4	.6	.6	.6	.6	.6	.6	.6	.6	.4	.3	.1	.1	.1					
CONTRACT			.1	.2	.4	.3	.3	.3	.3	.3										

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Power Processing, Distribution & Control; Power Transfer Across Rotating Joints

NO. 12, 7, 11 P-2 PP-7
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

Improve the technology of transferring power across a rotating joint from the solar array to the spacecraft.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1987

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes (new initiative)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Power distribution, power conditioning and high voltage systems

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Liquid metal slip rings offer a potential advancement in reducing noise, power loss, friction and in extending life.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

TITLE Power Processing, Distribution & Control; Power Transfer Across Rotary Joints

NO. 1,7,8,9,11/P-2/PP7 **THEME / W.G. / TASK**

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Using current design, subscale hardware will be put on life tests. A parametric design and analysis phase will investigate scaling problems to larger sizes and power levels. A fabrication task will look at problems of large size construction. An early flight test on shuttle will investigate operational problems.

7. ALTERNATIVE APPROACHES/OPTIONS Mechanical slip rings

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
1. Subscale life tests			△																	
2. Parametric Design & Ana			△		△															
3. FAB task					△	△														
4. Flt Tests								△												
MANPOWER (M-Y) INHOUSE			5	5	5	5	5	5												
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.05																	
CONTRACT			.1			.4	.5	.7												

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE Power Processing, Distribution & Control: Multi-KW Distribution System Technology

NO. 1,7,8,9,10, 11,12 / P-2 / PP-3
THEME / W.G. / TASK

DATE 4 / 29 / 76

2. OBJECTIVE
To demonstrate the technology readiness at high voltage DC power distribution system through use at a lab simulator

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1979

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes 506-23-34 R&D - 65.2K, IMS 4.8K

4 COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
To demonstrate technology readiness and performance advantages of high voltage DC distribution and control systems for large vehicles. Additional objectives are to evaluate the merits of solid state switchgear and multiplexed computer controlled supervision and control methods in conjunction with HVDC distribution.

LEVEL OF STATE OF ART

1 BASIC PHENOMENA OBSERVED AND REPORTED
2 THEORY FORMULATED TO DESCRIBE PHENOMENA
3 THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4 PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5 COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6 MODEL TESTED IN AIRCRAFT ENVIRONMENT
7 MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Power Processing, Distribution and Control:
Multi-KW Distribution System Technology

NO. 1, 7-12 / P-2 / PP-8
THEME / W.G. / TASK

DATE 4 / 28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

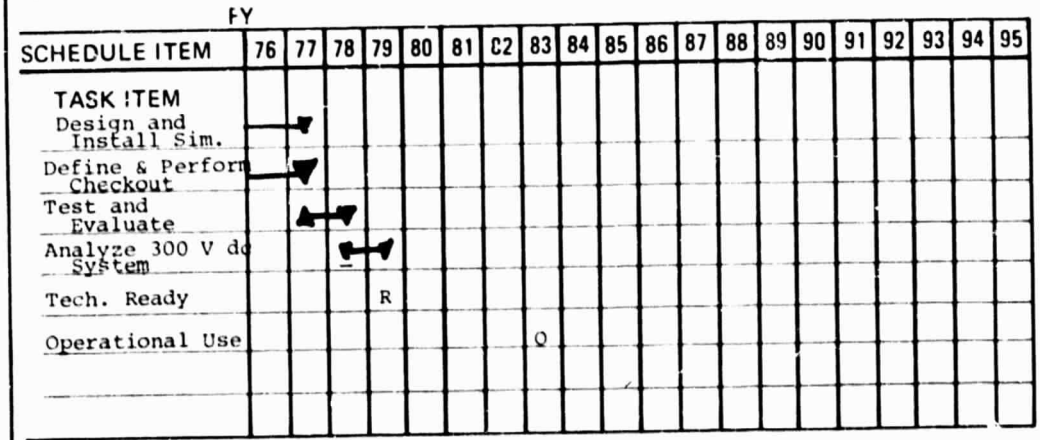
The Power Processing, Distribution and Control Study which was completed in late 1972 concluded that future multi-Kw power distribution systems should use voltages in excess of 100V dc, employ multiplexed digital supervision and control methods, and solid state controls. This effort has been initiated to implement this approach.

7. ALTERNATIVE APPROACHES/OPTIONS High voltage distribution is essential for the specified high power requirements.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

This relates to other proposed high voltage - high power proposed power components.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE		1.5	1.5	1.5																
MANPOWER (M-Y) CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
FUNDING (10^6 $) CONTRACT	.07	.07	.08	.07																

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE: Thermal to Electrical Conversion: Thermoelectric Systems

NO. 10/p-2/TE-1
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

Provide, data base on thermoelectrics for NASA, provide power degradation models for isotope thermoelectric system, provide techniques for integrating isotope power with spacecraft.

3. NEED ANALYSIS

a) LEVEL NOW [ ], WILL BE LEVEL [ ] UNDER EXISTING PLANS. N/A

b) REQUIRED ADVANCEMENT SHOULD BE TECHNOLOGY READY AT LEVEL [ ] FOR OPERATIONAL SYSTEM USE BY [DATE:] N/A

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] technology development (Check one or more)

f) DATA BASE CANDIDATE Yes, FY 76: 506-23-43 $286K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop radiation control technology for S/C.

Evaluate selenide thermoelectrics.

Develop high-performance thermoelectrics.

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE THERMAL TO ELECTRICAL CONVERSION:
THERMOELECTRIC SYSTEMS

NO. 10/P-2/TE-1
THEME / W.G. / TASK

DATE 4 / 28 / 76

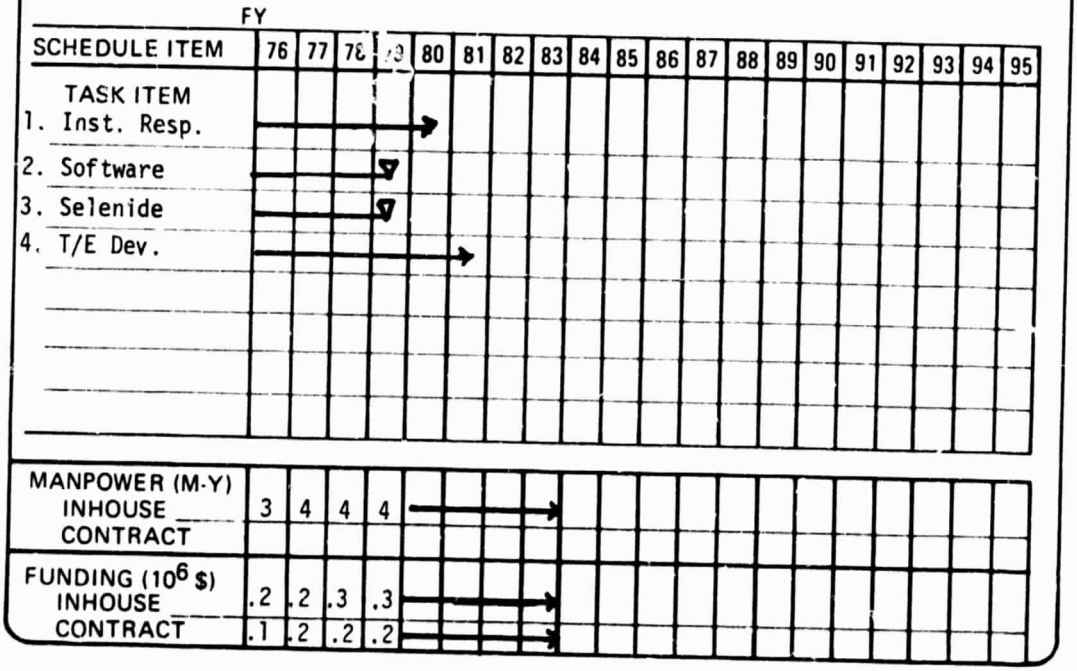
6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

1) Instrument response to radiation enviroment
2) Radiation software development
3) Selenide Evaluation
4) High Performance T/E Material Dev.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Thermal to Electrical:
High Temperature Brayton Power Conversion

NO. 1,7,8,10,12/P-2/ TE-2
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE
Acquire the technology for cost-effective, long-life, high-turbine-inlet-temperature Brayton conversion of heat from various energy sources to electric power for use in a variety of applications

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1995]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes: NEW START

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY (a) material selection and evaluation, (b) liquid-metal heat-pipe development, (c) solar concentrator development, (d) reactor development

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Demonstrate Brayton capabilities for turbine-inlet temperatures of 1500K to 1600K with 10-year expected lifetimes by 1985 and 20-year expected lifetimes by 1990.

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LEVEL
1 - STATE OF ART
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY FUNDAMENTAL EXPERIMENT OR MATHEMATICAL MODEL
4. EXPERIMENTAL PROOF OF PERFORMANCE DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Thermal to Electrical:
High Temperature Brayton Power Conversion

NO. 1,7,8,10,12/P-2 /TE-2
THEME / W.G. / TASK

DATE 4 /28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(a) high temperature blade and nozzle development
(b) bearing and mechanical design/development
(c) thermodynamic analysis
(d) rotating unit fabrication and test
(e) system design

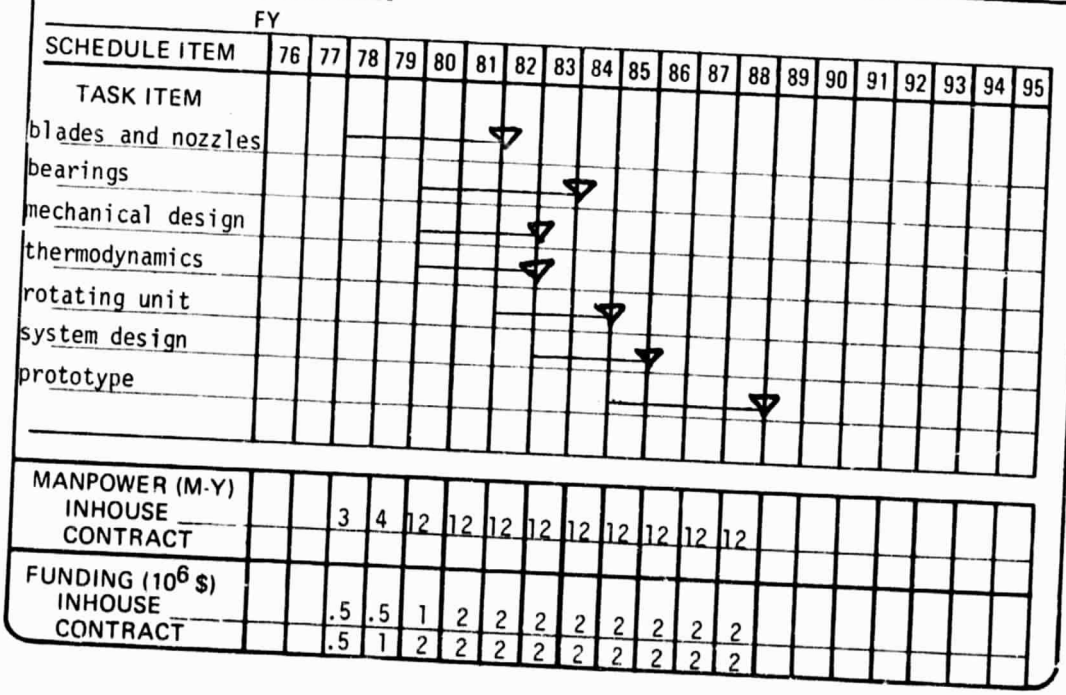
7. ALTERNATIVE APPROACHES/OPTIONS

Thermionic power conversion

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE THERMAL TO ELECTRICAL: PROTOTYPIC NUCLEAR THERMIONIC SPACE POWER MODULE

NO. 7,8,10,12/P-2/TE-3
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

ACCOMPLISH THE DESIGN AND ELECTRICALLY HEATED DEMONSTRATION OF A NUCLEAR-THERMIONIC-SYSTEM MODULE FOR A HEAT-PIPE-COOLED FAST REACTOR.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990] (EARLIEST)

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) RAT BASE CANDIDATE YES: 506-24-23 ($400K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

A) HEAT-PIPE-RADIATOR DEVELOPMENT, B) HEAT-PIPE-COOLED NUCLEAR-FUEL ELEMENT IN-PILE EVALUATION C) COMPONENT FAILURE-MODE ASSESSMENT, D) NEUTRON-SHIELDING DEVELOPMENT, E) HIGH-PERFORMANCE THERMIONIC CONVERSION

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

DEMONSTRATE SATISFACTORY STEADY-STATE AND TRANSIENT BEHAVIOR AND PERFORM RELIABILITY ANALYSES FOR AN EXTRAPOLATED SPECIFIC MASS OF 20 KG/KWE AND A LIFETIME OF 2 YEARS AT A SIMULATED POWER LEVEL OF 500 KWE.

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SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Prototypic Nuclear Thermionic Space Power Module

NO. 7,8,10,12/P-2/TE-3
THEME / W.G. / TASK

DATE 4 /28 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(a) Transfer technology from system R&T programs, (b) Provide a preliminary power subsystem design and experimental component development and qualification tests, (c) Fabricate and integrate a 5-heat-pipe system module for electrically-heated demonstration of performance before completion and release of engineering model design.

7. ALTERNATIVE APPROACHES/OPTIONS

None available

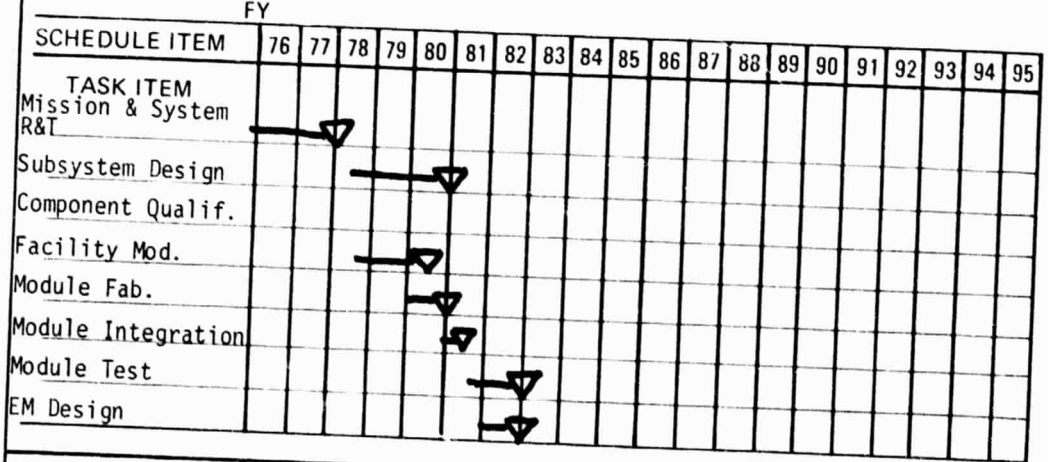
8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

R&T Base Programs:

(a) High-Performance Thermionic Conversion (RTOP 506-24-21)

(b) Thermionic Systems Technology (RTOP 506-24-23)

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M·Y)																				
INHOUSE	4	4	15	15	15	15	15													
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	0.2	0.2	1	2	2	2	0.8													
CONTRACT	0.2	0.2	2	2	2	2	0.7													

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE THERMAL TO ELECTRICAL: THERMOPHOTOVOLTAIC POWER CONVERSION TECHNOLOGY

NO 1,7,8,9,10,11,12/P-2/TE-4
THEME / W.G. / TASK

DATE 4 / 26 76

2. OBJECTIVE EVALUATE THE FEASIBILITY OF OBTAINING EFFICIENCIES APPROACHING 30% IN THE CONVERSION OF SOLAR ENERGY THE DESCRIBED SPECIALIZED APPLICATION OF PHOTOVOLTAICS.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [4] FOR OPERATIONAL SYSTEM USE BY [DATE: 1979]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE YES

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY LIGHT WEIGHT CONCENTRATORS

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

THE SUN'S ENERGY IS FOCUSED UPON A BODY, HEATING IT TO APPROXIMATELY 3000°K. AT THIS TEMPERATURE, THE BLACKBODY RADIATION THAT IS EMITTED MORE NEARLY MATCHES THE RESPONSE OF A SOLAR CELL. CELLS COVER THE INSIDE OF A SURFACE WHICH ENCLOSES THE HEATED BODY. THE BLACKBODY RADIATION, EXCEPT FOR THE LONG WAVE LENGTHS, IS ABSORBED BY THE SOLAR CELLS CONVERTING PART OF IT INTO ELECTRICAL ENERGY. THE LONG WAVE LENGTHS ARE TRANSMITTED THROUGH THE CELLS AND REFLECTED BY THE REAR SURFACE BACK ONTO THE HEATED BODY, WHERE IT IS ABSORBED AND USED TO HELP MAINTAIN THE 3000° TEMPERATURE.

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SPACE TECHNOLOGY NEED

FORM NO. I

TITLE Thermophotovoltaic Power: Conversion Technology

NO. 1,7,8,9,10,11,12/ P-2/TE4

THEME / W.G. / TASK

DATE 4 /28 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

This proposed effort evaluates the feasibility of a specialized application of photovoltaics. The approach is to build and test one or more scaled units to demonstrate feasibility.

7. ALTERNATIVE APPROACHES/OPTIONS

The alternate approach is to use larger solar arrays or nuclear sources.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Analysis of Concept		▼																		
Design Test Unit		▼																		
Test Unit		▲	▼																	
Analysis of Test			▼																	
Determine Feasibility			▼																	
MANPOWER (M-Y)																				
INHOUSE		2	3																	
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE																				
CONTRACT		.05	.15																	

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE Thermal to Electrical: High-Performance Thermionic Conversion

NO. 1, 7, 8, 10, 12/P-2/TE-5
THEME / W.G. / TASK

DATE 4 / 26/76

2. OBJECTIVE
Acquire the technology for economical, durable, high-efficiency thermionic conversion of heat from various energy sources to electric power for use in a variety of applications.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1995 to 2000

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [x] ANALYSIS [x] RESEARCH [x]
GRD TEST [x] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes: 506-24-21 ($631K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY (a) material selection and evaluation, (b) liquid-metal heat-pipe development, (c) solar concentrator development, (d) reactor development

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Achieve converter efficiences of 30 percent or greater with 10-year expected lifetimes by 1985 and 20-year expected lifetimes by 1990.

LEVEL OF STATE OF ART
1. CONCEPT PLAUSIBILITY OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Thermal to Electrical:
High-Performance Thermionic Conversion

NO1,78,10,12/P-2/ TE-5
THEME / W.G. / TASK

DATE 4 /27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

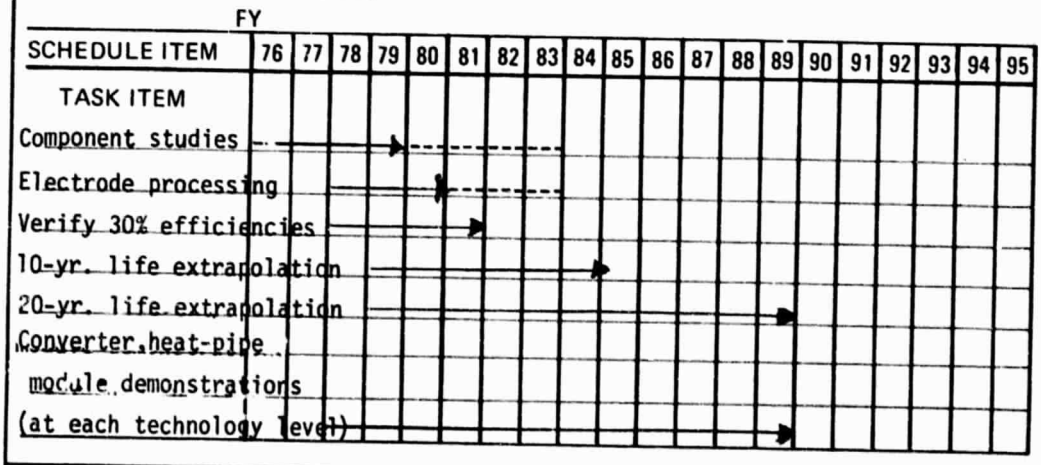
Provide the technology to produce better emitters, collectors, and ion generators through coordinated contract, grant, and in-house theoretic and experimental studies (NASA Thermionic-Energy-Conversion (TEC) Applied-Research and-Technology (ART) Program). With the resulting reduced electrode work functions, electron reflections, and interelectrode losses demonstrate more efficient thermionic converts. The acquired TEC-ART information will allow designs of more effective space power systems

7. ALTERNATIVE APPROACHES/OPTIONS Possibility of high-temperature Brayton (new start)

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-24-31, 506-16-31, 504-24-22

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	7	7	10	15	15	15	10	8	7	5										
CONTRACT	20	20	30	40	50	50	30	25	20	15										
FUNDING (10^6 $) INHOUSE	0.4	0.4	0.6	0.8	1.0	1.0	0.8	0.8	0.6	0.5										
CONTRACT	0.7	0.7	1.4	1.5	2.0	2.0	1.5	1.5	1.0	1.0										

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Thermal to Electrical: Light-Weight, Radiation Resistant Solar Concentrator

NO. 1,7,8,10, 11,12, P-2/TE-6
THEME / W.G. / TASK

DATE 4 /26 / 76

2. OBJECTIVE

Achieve concentration ratios greater than 10^3 with configuration stabilities appropriate for pointing accuracies of 0.1 degree utilizing light-weight construction and nondegrading surfaces.

3. NEED ANALYSIS

a) LEVEL NOW [1], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes: New start

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY (a) advanced steering capability, (b) high-temperature-receiver development

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Acquire the technology necessary for solar concentrators with weights less than 1 kg/m^2 to produce receiver temperatures of 1600 K to 1800 K without significant degradation from 11-to-37 Mev protons with a fluence of $3x10"/cm^2$.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF 2

TITLE THERMAL TO ELECTRICAL:

~~LIGHT-WEIGHT, RADIATION-RESISTANT~~

SOLAR CONCENTRATOR

NO. 1,7, 8, 10, 11, 12, P-2/TE-6

THEME / W.G. / TASK

DATE 4 / 07 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(a) light weight substrate development

(b) compatible reflective surface coatings

(c) protective cover materials

(d) irradiation test, documentation

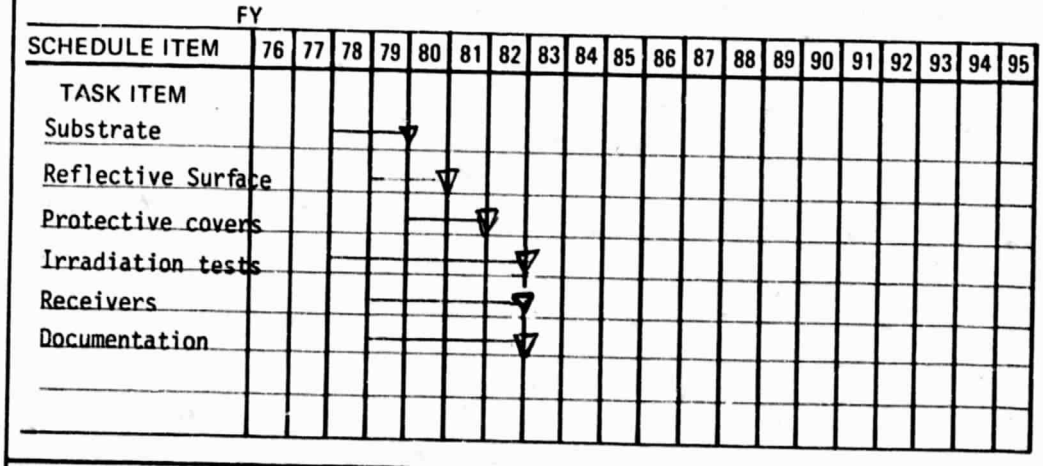
(e) high temperature receive development

7. ALTERNATIVE APPROACHES/OPTIONS

None Available

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE			4	6	8	8	8													
CONTRACT			6	6	8	8	8													
FUNDING (10^6 $)																				
INHOUSE			0.5	0.8	1	1	1													
CONTRACT			0.5	0.8	1	1	1													

SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE Thermal To Electrical: Heat Pipes with High Thermal Power Densities

NO. 1,7,8,10,12/P-2/TE-7 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

2. OBJECTIVE

Establish materials, designs, and processing for efficient, durable, economical heat pipes for space applications involving transport of high thermal power densities at intermediate and high operating temperatures.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE:]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes: 506-16-31 ($400)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

(a) Materials compatibilities.

(b) Materials with high static and dynamic strengths or high temperatures.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Achieve thermal power densities greater than 10 W/cm^2 for intermediate temperatures and lifetimes greater than 10 years by 1985 and 20 years by 1990 for high temperatures.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Thermal to Electrical: Heat Pipes with High Thermal Power Densities

NO. 1,7,8,10,12/P-2/TE-7
THEME / W.G. / TASK

DATE 4 /28 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

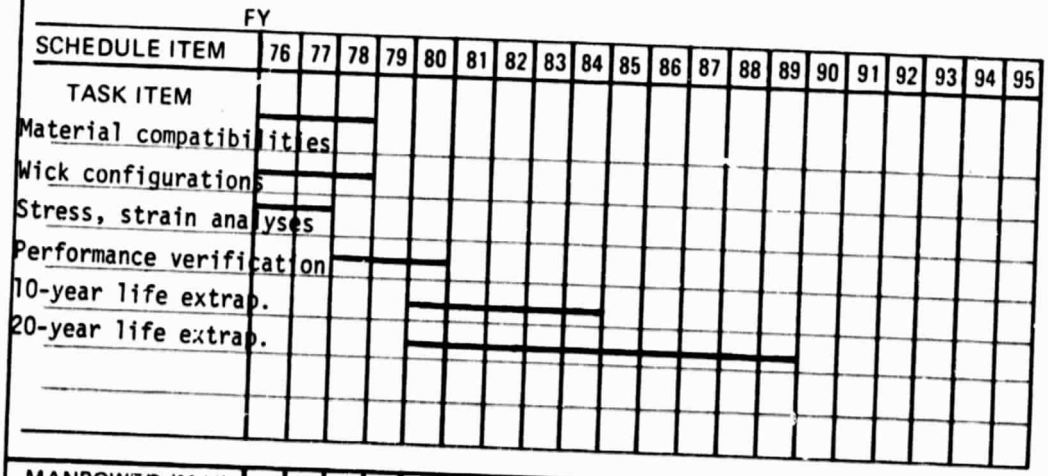
Screen compatibilities, evaluate performances, and determine lifetimes for selected heat-pipe-fluid, wick, and envelope materials; designs; processing; and operating conditions. Use these results to propose and specify high-power-density heat pipes for space applications in the intermediate- and high-temperature operating ranges.

7. ALTERNATIVE APPROACHES/OPTIONS Conventional heat-transfer methods

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-16-31, 506-24-21, 506-24-31

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	3	3	5	5	8	8	8	5	5											
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.16	.2	.3	.3	.5	.5	.5	.5	.5											
CONTRACT	.17	.2	0.4	.5	1.0	1.0	1.0	1.0	1.0											

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Thermal to Electrical:
Gas-Core-Reactor Energy Conversion

NO. 1, 7, 8 /P-2/ TE-9
THEME / W.G. / TASK

DATE 4 /27/76

2. OBJECTIVE

Utilize the very high temperatures of fissioning plasma cores in nuclear reactors to provide multimegawatt power economically ~~and with low weights.~~

3. NEED ANALYSIS

a) LEVEL NOW [0], WILL BE LEVEL [1] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [3] FOR OPERATIONAL SYSTEM USE BY [DATE: 2000]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] _____ (Check one or more)

f) RGT BASE CANDIDATE Yes : RTOP 506-24-11

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY (a) Separation capabilities (buffer gas and ~~fission products from fuel, (b) high-temperature working-fluid~~ containment, (c) gas-core-reactor technology.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Determine the technology required to utilize the very high reactor-plasma temperatures in obtaining higher-than-conventional energy-conversion efficiencies.

For example an MHD generator operates with fluid temperatures much higher than those for many other converters. So MHD might ~~operate on the partially recycled reactor fluid.~~ And conversion cascading (such as MHD with thermionics and perhaps Brayton) might serve well. Or special energy converters (like very high ~~energy-coherent electromagnetic-beam generators~~) might be developed.

In any event the advancement required is the establishment of appropriate energy-conversion technology for the gas-core-reactor.

7

LEVEL OF STATE OF ART
1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Thermal to Electric: Gas-Core-Reactor Energy Conversion

NO. 1.7.8./P-2/TE-9
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(a) Power conversion concepts in temperature regimes above 5000°K.

(b) Cycle temperature/efficiency trade-offs.

(c) Topping and bottoming cycle criteria.

(d) Power conversion system definition studies.

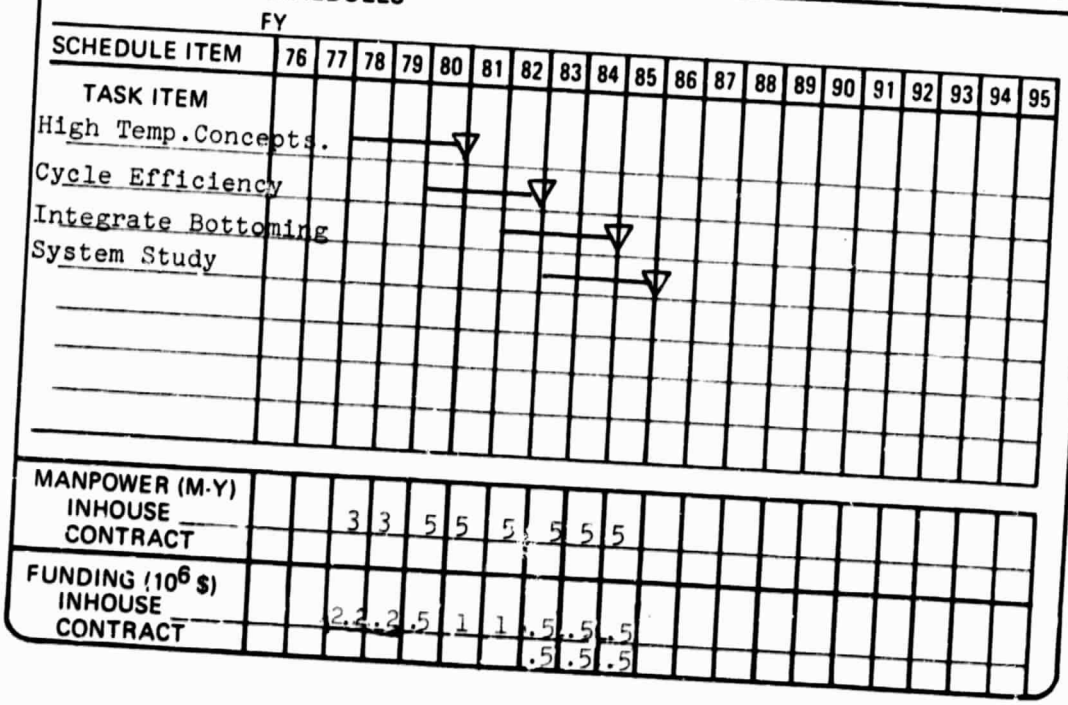
7. ALTERNATIVE APPROACHES/OPTIONS

Solid-core reactor energy conversion

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None

9. TECHNOLOGY SCHEDULES



LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE THERMAL TO ELECTRICAL: SOLAR FURNACES FOR SPACE APPLICATIONS

NO. 1, 8/P-2/TE-10 (THEME / W.G. / TASK)

DATE 4 / 29 / 76

2. OBJECTIVE

Provide the technology necessary for effective utilization of solar furnaces for materials processing and manufacturing in space.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1995]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes: New Start

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY a) Large-structures stabilization and pointing, b) lightweight, long-life, high-temperature thermal insulation, c) high-concentration-ratio solar collectors.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Attain temperatures near 5000K with durable, economical solar furnaces in space: Critical elements are light-weight, long-life, high-concentration-ratio solar collectors; precise pointing capabilities with space-effective structures; and furnace cavities with high radiation reception and retention. Processing will involve at least photochemistry, mass spectroscopy, mineral separation, vapor deposition and ion implementation with particular adaptations for metal refining and fissionable materials.

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE THERMAL TO ELECTRICAL: SOLAR FURNACES FOR SPACE APPLICATIONS

NO. 1, 7, 8 / P-2/TE-10
THEME / W.G. / TASK

DATE 4 /29 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

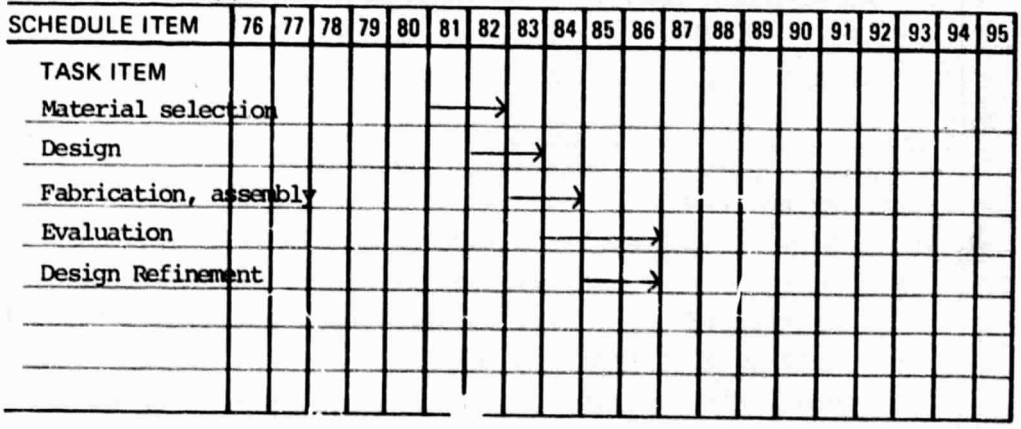
Select from the solar-concentrator technology base highly reflective, radiation resistant materials and structures suitable for precise, stable contours and pointing. Use furnace designs with high radiation reception and retention capabilities. Design, fabricate, and evaluate a scalable model and provide scale-up plans.

7. ALTERNATIVE APPROACHES/OPTIONS Furnance utilizing a gas-core reactor.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Solar-concentrator technology base.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE						4	4	4	4	4	4									
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE						0.2	0.2	0.4	0.5	0.2	0.2									
CONTRACT						0.2	0.3	0.8	1.0	0.5	0.5									

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE THERMAL TO ELECTRICAL: NUCLEAR FUELS AND BREEDER STOCKS FROM LUNAR SOIL

NO. 1,7,8/ P-2/TE-11
THEME / W.G. / TASK

DATE 4 /29 / 76

2. OBJECTIVE

Investigate lunar uranium and thorium material phases and availability, and determine practical methods for in-situ processing and/or separation for fuel production.

3. NEED ANALYSIS

a) LEVEL NOW [1], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 2000]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [XX] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes: New Start

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) Quantify, categorize raw materials and regoliths.

(2) Evaluate alternate methods of mineral separation, such as vaporization, mass spectroscopy, photochemistry, etc.

(3) Provide a test demonstration of the preferred separation, processing method and establish a preliminary functional specification for the lunar base system.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

TITLE THERMAL TO ELECTRICAL: NUCLEAR FUELS AND BREEDER STOCKS FROM LUNAR SOIL

NO. 1,7, 8/ P-2/TE-11
THEME / W.G. / TASK

DATE 4 /29 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

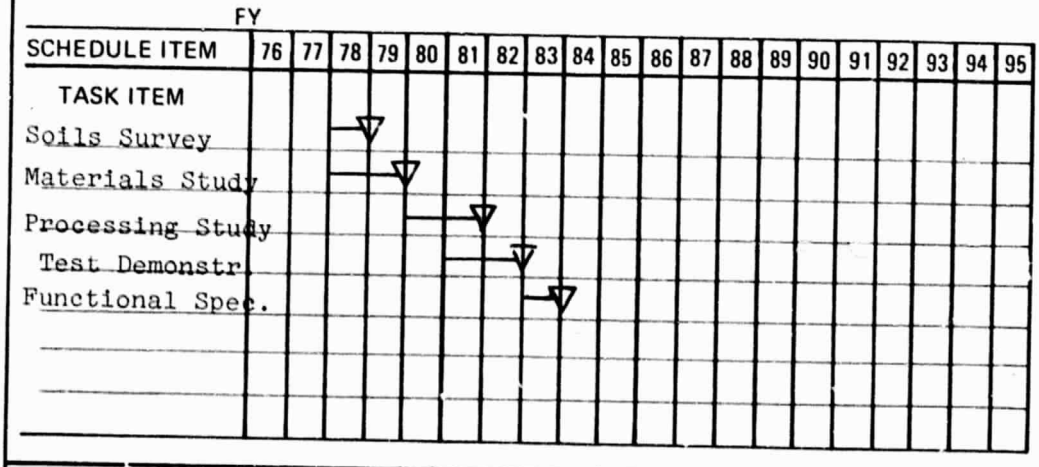
(a) Lunar soils survey
(b) Materials evaluation, categorization
(c) Processing analysis
(d) Test demonstration
(e) Prepare functional specifications

7. ALTERNATIVE APPROACHES/OPTIONS None

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Other lunar materials studies

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE			2	2	4	4	4	2												
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.2	.4	.5	.5	.5	.3												
CONTRACT																				

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE TRANSMISSION ; MICROWAVE Transmission NO. 07/ P2/TX-1
THEME / W.G. / TASK

DATE 4 /29/ 76

2. OBJECTIVE

PROVIDE A TRANSMISSION MEDIUM FOR THE TRANSFER OF POWER BY USE OF MICROWAVE TRANSMITTER (MPTX) AND A RECEIVER/ CONVERTER (REC-TENNA)

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] TECHNOLOGY DEVELOPMENT (Check one or more)

f) B&T BASE CANDIDATE NEW INITIATIVE CANDIDATE FY'78

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY HIGH POWER "CW" TRANSMITTER FOR RF (MICROWAVE, I.E., "S" BAND) AND COMPLIMENTARY RECEIVING CONVERTER.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

1) REQUIRE MEGAWATTS PLUS HARDWARE CAPABILITY TO GENERATE, TRANSFER TO ANTENNA, ANTENNA HARDWARE (BEAMFORMING), STABILIZING STRUCTURE FOR ORIGINATION OF RF POWER.

2) REQUIRE STUDY FOR UNDERSTANDING NATURE OF SUPER POWER ELECTROMAGNETIC ("S" BAND) PROPAGATION PATH NORMAL TO EARTH (?) ENVIRONMENTAL EFFECTS, ENERGY SCATTER EFFECTS, EMI CAPABILITY.

3) REQUIRE RECEIVER/CONVERTER HARDWARE DEVELOPMENT FOR CAPTURE AND CONVERSION OF RF ENERGY AT RECEIVING STATION.

SPACE TECHNOLOGY NEED FORM NO. I

TITLE TRANSMISSION: MICROWAVE TRANSMISSION NO. 07/P-2/Tx-1

THEME / W.G. / TASK

DATE 4 / 29 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

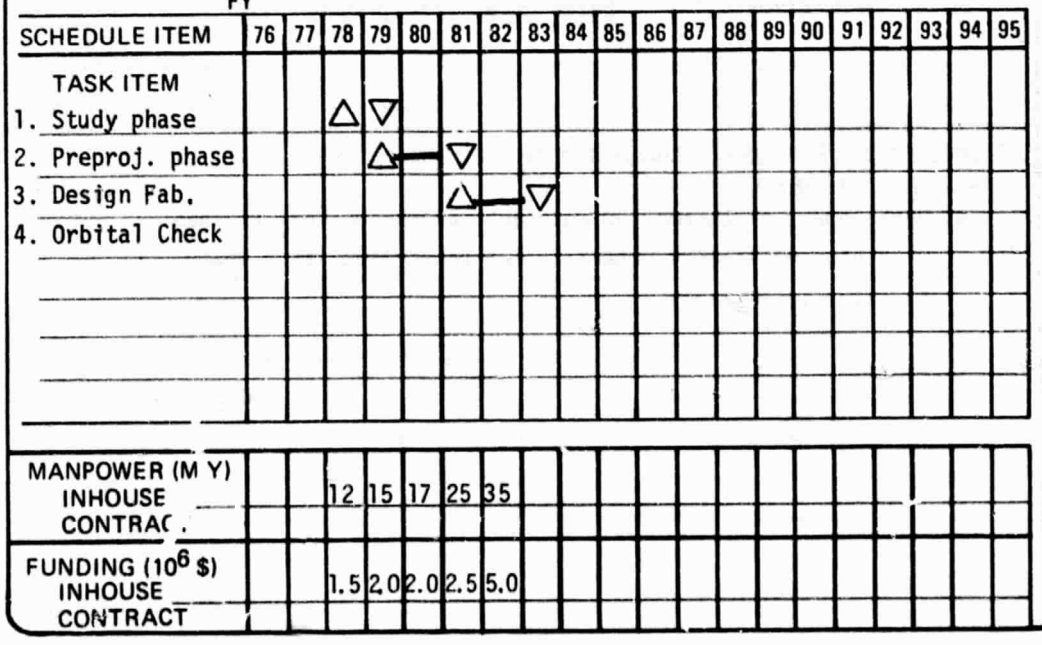
A. Develop a standard subarrary module for CW S-Band

B. Determine pilot beam steered, retrodirective array beam efficiency, pointing accuracy, starting transient, side lobe level and RFI measurements on a space based, flexible surface, phased array antenna.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE Transmission: Laser Power Converter

NO. 07 / P-2 / TX-2
THEME / W.G. / TASK

DATE 4 / 29 / 1976

2. OBJECTIVE

Provide efficient means to receive and convert laser radiation (5μM) to electrical power

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: [1978]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Laser Power Transmitter

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- Development of thermal or resonant absorption heat engines with high efficiency potential for converting laser beams to electrical energy.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE Transmission: Laser Power Transmitter NO. 07 / P-2/TX-3
THEME / W.G. / TASK

DATE 4 / 29 / 1976

2. OBJECTIVE Provide high power laser transmitter for use in space

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1987

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Laser power converter, laser propulsion, Large power systems for space.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

o 60% efficient, closed-cycle, electrogasdynamic CO laser designed and qualified for space usage.

o 30-meter objective optical system qualified for directing laser beam with 10^{-7} radian accuracy

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE ELECTROCHEMICAL CONVERSION
LIGHT-WEIGHT FUEL CELL

NO. 1, 7, 8, 12/P-2/ECC 1
THEME / W.G. / TASK

DATE 4 / 28 / 76

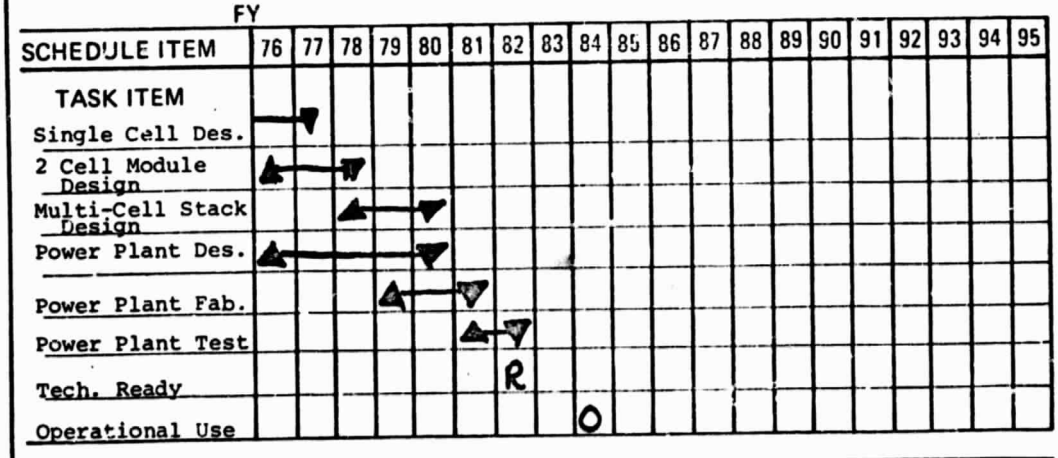
6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

This is an on-going task and the approach is to design, fabricate, test components and modules, and demonstrate the complete power plant operation using propellant grade reactants. It is a coordinated program between LeRC and MSFC. The plan is to develop a modular system.

7. ALTERNATIVE APPROACHES/OPTIONS There is no alternate for some of the specified requirements especially for some Space Transportation Systems.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	3	2	2	2	2	2														
CONTRACT																				
FUNDING (10^6 $) INHOUSE		.01	.01	.01	.01	.01														
CONTRACT	.225	.25	.25	.25	.25	.1														

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SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Power Systems - Automated Power Systems Management (APSM)

NO. 10, 11, 12 / p-2/s-2
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE
To develop power systems capable of automatically performing monitoring, computational, command, control, and self-test and repair functions.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1983]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] development (Check one or more)

f) R&T BASE CANDIDATE Yes; RTOP 506-23-35; FY 76 = $72K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY none

5. SPECIFIC TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- Evaluate the mission sets to determine the degree of required automation.
- Develop APSM for each type of power system.
- Requires hardware and software.
- APSM unique hardware includes many monitors (that is, sensors), analog-to-digital conversion equipment, microprocessor based computers. Of these, the major development item are the sensors which should be small, low-loss devices since many will be needed: sensors are the major hardware challenge.
- The major design challenge is to provide APSM which will operate hardware efficiently, achieve long-life and reliability for the power system, and permit autonomous spacecraft operation.

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 3

TITLE
Power Systems
Automated Power Systems Management (APSM) - Planetary

NO. 1.10 / P-2 / S-2
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

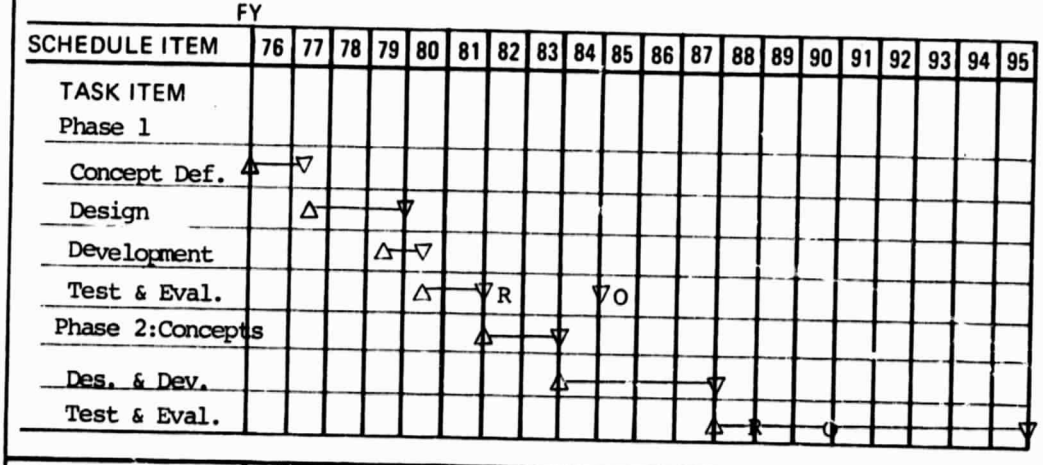
- Develop APSM for planetary exploration missions
- Perform in two major phases: 1st achieves technology readiness by FY 81 for 1980's missions; and phase 2 for 1990's for automated study facilities of theme 10
- Develops advanced sensors for power system monitoring, develops sensor system, computer software and synthesizes systems including these with power hardware, data processing, and microprocessor-based computer.

7. ALTERNATIVE APPROACHES/OPTIONS NONE. Automated capability is needed for all planetary missions due to long communication and reaction times which preclude ground control.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

- On-going RTOP 506-23-35 covers 1st phase
- Expansion for phase two is needed

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)	.3	2	2.5	3	3.5	2.2	1	1	2	3	3	3	2	2	2	2	2	2	2	2
INHOUSE																				
CONTRACT																				
FUNDING (10^6 $)	.1	.2	.2	.3	.3	.2	.1	.1	.2	.3	.4	.4	.2	.2	.2	.2	.2	.2	.2	.2
INHOUSE																				
CONTRACT	.1	.2	.3	.3	.1	0	0	.1	.5	.5	.5	.5	.1	.1	.1	.1	.1	.1	.1	.1

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 3 OF 3

TITLE Power Systems:
Automated Power Systems Management
for Earth Orbital Missions

NO. 7,8,11 P-2 S-2
THEME / W.G. / TASK

DATE 4/27/76

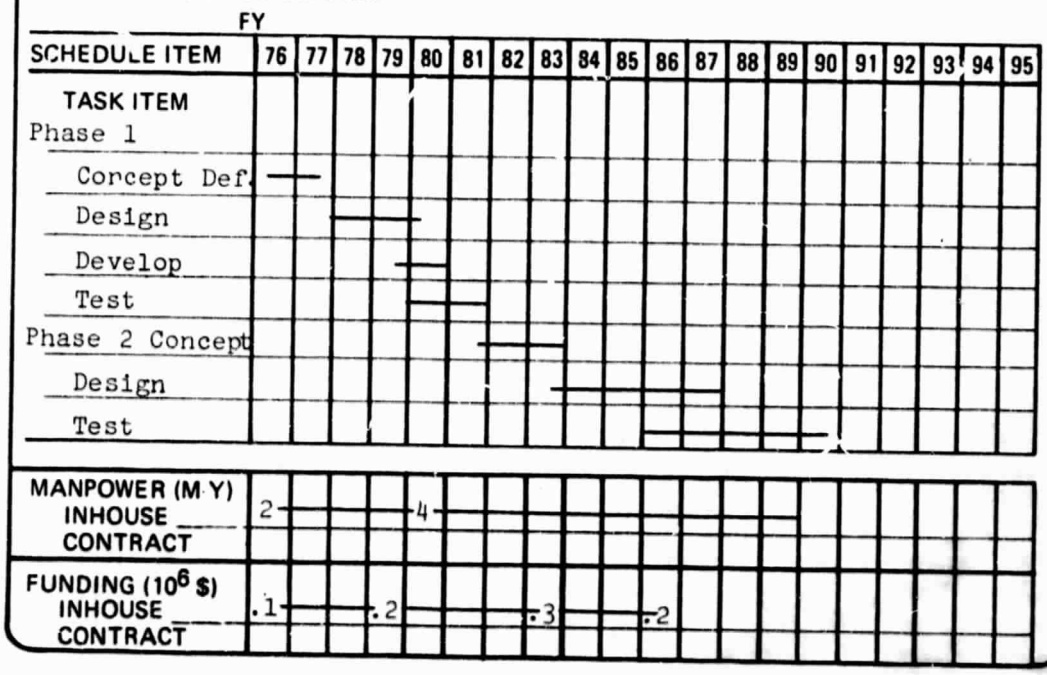
6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- Develop advanced automated system management concepts
- Establish technology readiness by 1980
- Develop necessary sensors for system monitoring including computer software, data processing, etc.

7. ALTERNATIVE APPROACHES/OPTIONS Automated capability is needed for all earth orbital missions.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)
506-23-35 However, expansion is required to include earth orbital missions.

9. TECHNOLOGY SCHEDULES



REVISED: Supersedes Previous Issue dated 4/26/76

SPACE TECHNOLOGY NEED FORM NO. 1

1. TITLE Power Systems (new initiative) NO. 1, 10/P-2/S-4 THEME / W.G. / TASK

Advanced Power Systems Technology

DATE 4 / 28 / 76

2. OBJECTIVE

Achieve technology readiness of power systems for Solar Exploration missions.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE:10-1-79]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [ ] GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [X] Development (Check one or more)

f) R&T BASE CANDIDATE FY76=0, FY77 overguideline RTOP; will be New Initiative for FY78 start.

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY (1) High temperature solar arrays, PC1 and (2) improved rechargeable batteries having higher WHR/KG, e.g. ES 1,2,3 and improved nickel-hydrogen batteries.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- Provides high temperature, light-weight power sources (e.g. solar thermoelectric generators and gallium-arsenicle solar cells) for Mercury orbiter mission spacecraft which will be exposed to extremely high thermal loading due to sun and planet influence. Also must provide lightweight high watts/KG power system to minimize mass to be injected into orbit. System concepts studied and trade offs done.
- Develops power system technology for solar exploration facilities needed starting 1990. Includes concept work, planning, and development of advanced sources, energy storage, power processing, and advanced systems for 10 - 25 year applications in planetary environments at power levels of 1 watt to 1 megawatt.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I** — PAGE 2 OF 2

TITLE Power Systems

Advanced Power Systems Technology

NO. 1,10/P-2/S-4 — THEME / W.G. / TASK

DATE 4 /28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- Broad Goal: Power system definition (concept design) + hardware technology readiness for solar exploration theme 10.
- Phase I: PS for Mercury Orbiter Mission Launch early 80's. Define requirements, trade-off competing sources, identify hardware needed and develop hardware.
- Phase II: Develop sources, energy storage, power systems concepts for inner and outer planet study facilities.

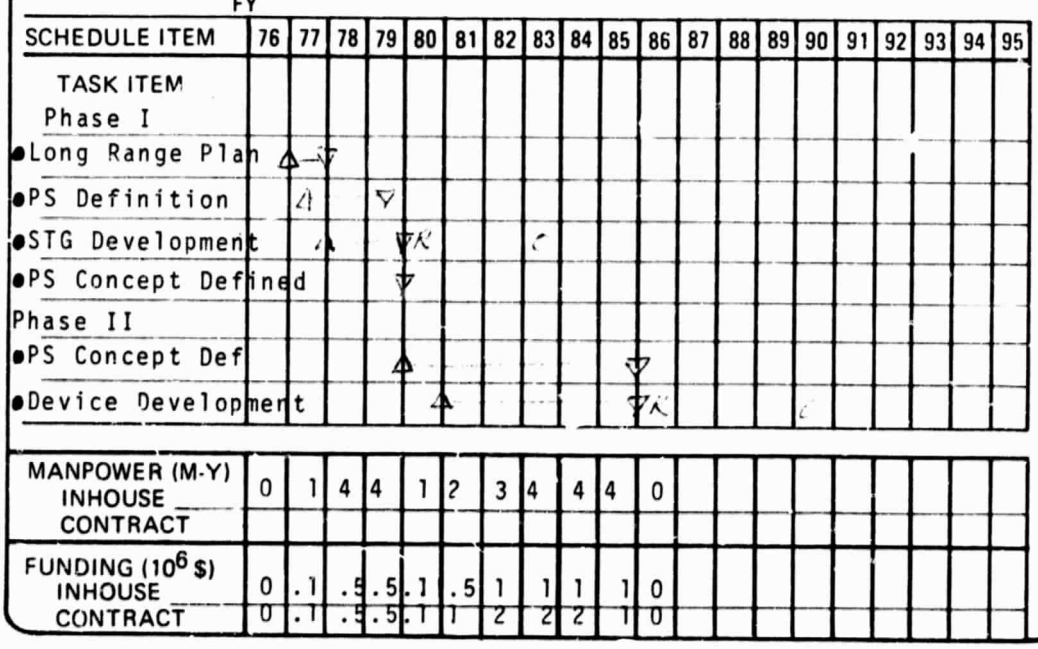
7. ALTERNATIVE APPROACHES/OPTIONS None. These missions need advanced systems approaches, sources, energy storage, and power processing systems.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

On-Going = None

- Proposed overguideline RTOP for FY TR/77 start for Phase I. Need additional program for Phase II.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	0	1	4	4	1	2	3	4	4	4	0									
CONTRACT																				
FUNDING (10^6 $) INHOUSE	0	.1	.5	.5	.1	.5	1	1	1	1	0									
CONTRACT	0	.1	.5	.5	.1	1	2	2	2	1	0									

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Power Systems - Power System Generation and Distribution Bus Voltage Technology

NO. 1, 7-12/p-2/s-5
THEME / W.G. / TASK

DATE 4 /26/ 86

2. OBJECTIVE
To select the voltage level(s) at which power will be generated and distributed to users in high-power, greater than 100 kw.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT -- SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] technology development (Check one or more)

f) R&T BASE CANDIDATE Yes. New initiative candidate.

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

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5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- High-power systems (above 100 kw) should be designed to operate at high voltages to achieve low current levels and avoid high copper losses and minimize the current handling capacity of power processing hardware.
- Perform system studies to determine acceptable voltage levels to minimize inefficiency and hardware design impact. For example, should solar arrays develop the voltage directly, should regulation be performed at the array, and over what range of voltage can regulators, invertors, etc., operate safely and efficiently?
- Answers will be via analyses and hardware development and test.

C-2

SPACE TECHNOLOGY NEED FORM NO. I

TITLE Power Systems

Power System Generation and Distribution Bus Voltage Technology

NO. 1,7-12/P-2/ S-5
THEME / W.G. / TASK

DATE 4 /28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

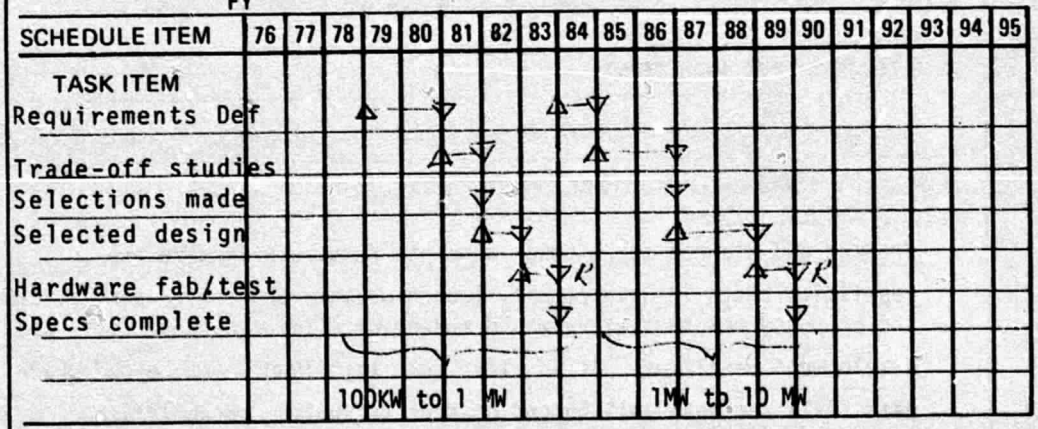
- o Definition of user power, voltage, current needs for S/C exceeding 100 KW.
- o Trade-off of voltage and current levels used at source, power conversion and processing, and distribution functions. Study to select optimum system and hardware approach for each function.
- o Selected hardware development and test to verify approach.
- o Develop standard specifications for high power systems.

7. ALTERNATIVE APPROACHES/OPTIONS None. High-current, high-power systems are inefficient and probably unworkable.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None. Plan below for R&T base to support MSPP, Global service, solar exploration operational need dates.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)	0	0	0	1.5	2	3	3	3	1	2	.2	3	3	3						
INHOUSE																				
CONTRACT																				
FUNDING (10^6 $)				.1	.2	.2	.3	.5	.1	.2	.2	.5	.8	.5						
INHOUSE																				
CONTRACT				.			.1	.2	0			.2	.4	.2						

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE POWER SYSTEMS: (New Initiative)
Project Oasis

NO. 1 - 12/p-2/S-6
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE
Determine the need, feasibility, and configuration of a long-life orbiting electrical power utility station for multimission space application.

3. NEED ANALYSIS

a) LEVEL NOW [1], WILL BE LEVEL [1] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: [1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Hardware demonstration (Check one or more)

f) R&T BASE CANDIDATE Yes - FY 78 New Initiative

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY
All other p-2 submissions

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Present and planned space power concepts require expensive and repetitive costs in development, launch weight, and energy limitations. The proposed new initiative would reduce or eliminate these costs and development penalties. It is clear that late 1980's and beyond power needs will increase well beyond present technology capabilities.

LEVEL OF STATE OF ART
1. CONCEPT FORMULATED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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OF POOR QUALITY

SPACE TECHNOLOGY NEED FORM NO. I

TITLE POWER SYSTEMS:
PROJECT OASIS

NO. 1-12/P-2/S-6
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- 100 kw DEMONSTRATION OASIS SYSTEM -

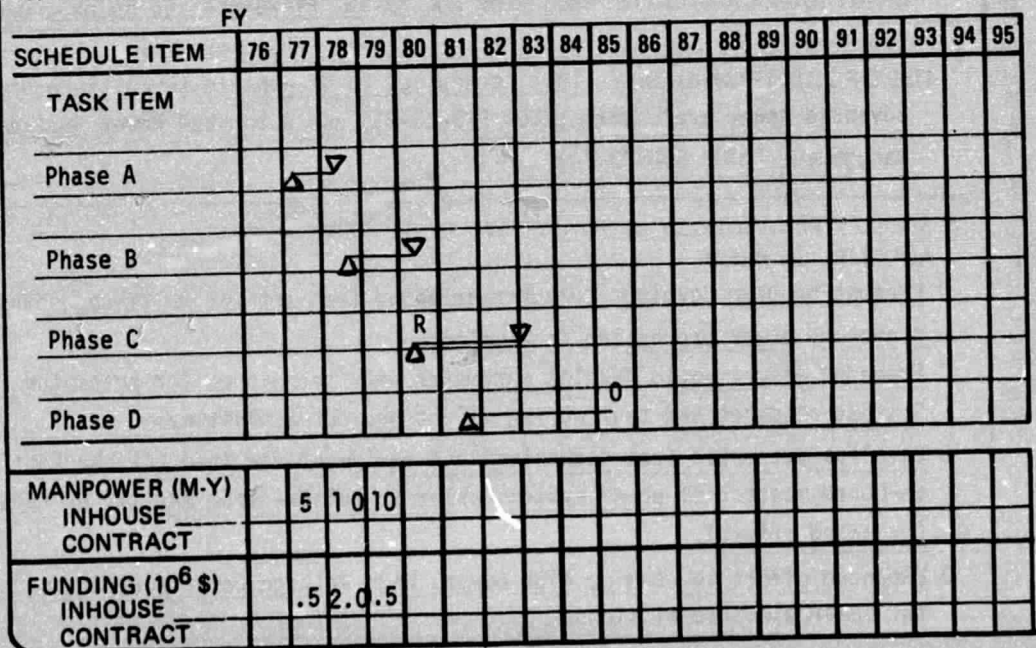
Phase A Needs, feasibility, and requirements study
Phase B Preliminary design and tradeoffs
Phase C Final design
Phase D Fabrication
Launch and operational in FY 1985

7. ALTERNATIVE APPROACHES/OPTIONS NONE

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

NEW INITIATIVE

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Power Systems

Automated Test Techniques and Technology

NO. 1,7,8,9,10 11,12 P-2/S-7

THEME / W.G. / TASK

DATE 4 /27 / 76

2. OBJECTIVE

Automated test techniques and technology for advanced planetary power systems.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1980]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Development (Check one or more)

f) R&T BASE CANDIDATE Yes; RTOP 506-23-33; FY'76=65K; to be expanded

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY This technology to be applied to multi-redundant advanced power processors (RTOP 506-23-33) and Automated Power Systems Management (RTOP 506-23-35).

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

0 Present program develops computer oriented test set for multi-redundant planetary power processing in development.

0 Expanded effort would develop automated test techniques for Automated Power Systems checkout and test during flight project activities.

0 Develops automated test technology and equipment for in-orbit checkout of on-board spacecraft power systems prior to release from shuttle or ASTS (expanded effort).

0 Expanded effort to develop high power, high voltage power source simulators for solar electric missions.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

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SPACE TECHNOLOGY NEED FORM NO. I

TITLE Power Systems - Automated Test Techniques and Technology

1,6,7,8,9,10
NO. 11,12/P-2/S-7
THEME / W.G. / TASK

DATE 4 / 29 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- The computer oriented test set (CTS) will be based on a small, general purpose computer and appropriate peripherals. A variety of systems can be tested with minimum changes.
- The expanded effort to test the APSM function will use the ongoing effort as a baseline with additional technology developed as required.
- A fully automated test capability will be developed for the in-orbit checkout of power subsystem. It will be designed to be simple, light, sufficiently rugged, and operate reliably in a launch and zero gravity environment.
- A modular approach to developing high power and high voltage power source simulators (up to 1 MW, and up to 1000V) will be employed.

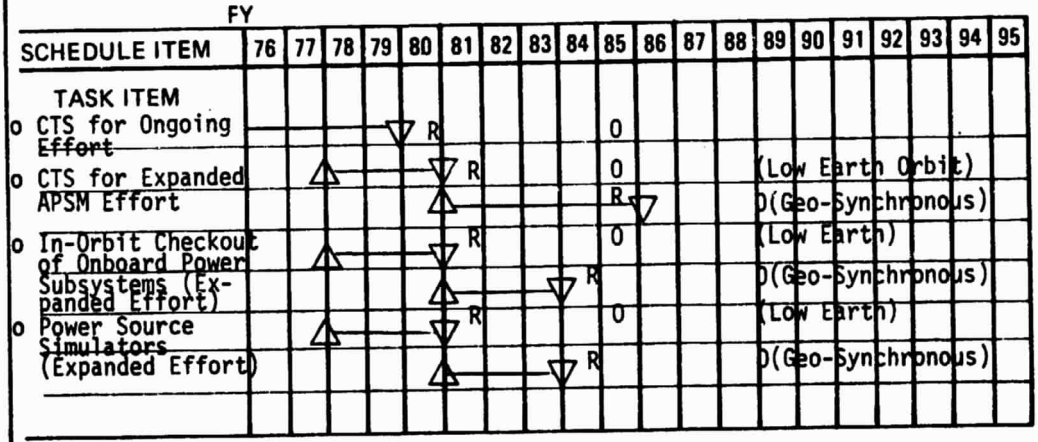
7. ALTERNATIVE APPROACHES/OPTIONS

No other reasonable alternatives exist.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Related to RTOP 506-23-33 and RTOP 506-23-35. Ongoing effort is indicated below, as well as an expanded effort.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	1	1.6	4	4	3	3	3	3	1	1										
CONTRACT																				
FUNDING (10^6 $) INHOUSE	0.1	0.1	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1										
CONTRACT				0.3	0.5		0.2	3												

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 1 OF 2

1. TITLE Power Systems: Large Power System for Lunar Base

NO. 1, 8/P-2/$-8
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

Establish the feasibility of a combined nuclear base load and solar swing load power system to support a 6-to-12-man lunar base operation for an extended time period.

3. NEED ANALYSIS

a) LEVEL NOW [1], WILL BE LEVEL [1] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1993

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes: New Start

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

a) lunar-surface construction capability, b) lunar-surface environment evaluation, c) cargo OTV developed for large PL to lunar orbit, d) emergency personnel vehicle

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Prove the capability for lunar-surface deployment of multihundred kW_e solar-array modules designed to operate in conjunction with a 500 kW_e nuclear thermionic power subsystem. Define the power processing technology required for lunar base operations, mining, materials processing, and fabrication.

SPACE TECHNOLOGY NEED — **FORM NO. I** — PAGE 2 OF 2

TITLE Power Systems: Large Power System for Lunar Base

NO. 1,8/P-2/S-8 (THEME / W.G. / TASK)

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

a. Power requirements estimates (solar and nuclear)
b. User requirements definition
c. Conceptual design
d. Lunar surface installation detail
e. Multi-hundred KWE module design (solar and nuclear)
f. Solar/Nuclear system integration studies

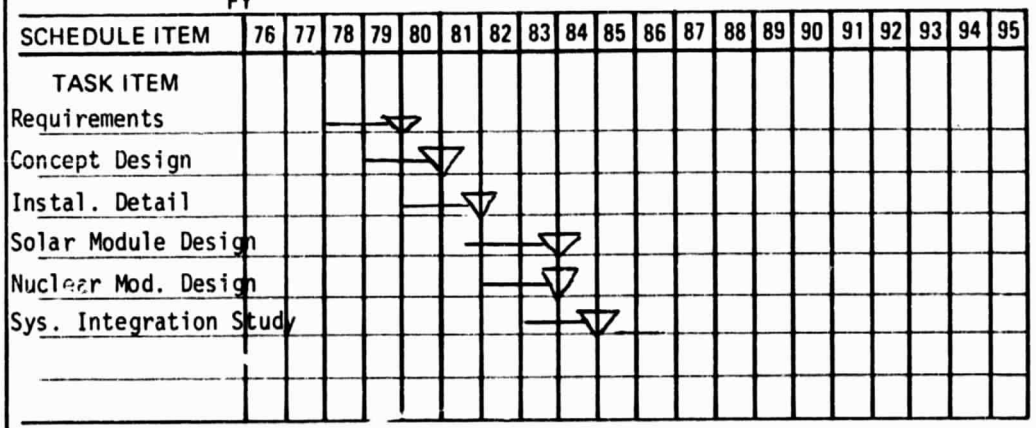
7. ALTERNATIVE APPROACHES/OPTIONS

NONE

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Space solar and nuclear systems technology

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE			2	4	6	6	6	6	6											
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.2	.4	.8	1.0	1.0	1.0	1.0											
CONTRACT			.1	.2	.4	.5	.5	.5	.5											

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE ENVIRONMENTAL INTERACTIONS: MEGAWATT POWER SYSTEM INTERACTION EXPERIMENT -NEW INITIATIVE-MID-80's

NO. 7,8,11/P-2/EI-1
THEME / W.G. / TASK

DATE 4 / 29 / 76

2. OBJECTIVE

TO DETERMINE THE SPACE PLASMA INTERACTIONS WITH THE VERY LARGE SOLAR POWER SYSTEMS PROPOSED FOR THE 90's. THIS WILL BE A SPACE FLIGHT TEST PROGRAM INCORPORATING THE TECHNOLOGY FOR THESE POWER SYSTEMS.

3. NEED ANALYSIS

a) LEVEL NOW [1], WILL BE LEVEL [1] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1989]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE NEW INITIATIVE IN MID-80's

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY HIGH VOLTAGE-HIGH POWER TECHNOLOGY, ENVIRONMENTAL INTERACTION, POWER TRANSMISSION

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- UTILIZE SPHINX B/C PROGRAM RESULTS.
- DEVELOP MODEL FOR SCALING TO LARGE SIZE AND LARGE POWERS
- DEVELOP PROGRAM TO INCORPORATE THE HIGH POWER TECHNOLOGY INTO FLIGHT TEST.
- BUILD AND FLY MISSION.

LEVEL OF STATE OF ART

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

TITLE Environmental Interactions: Megawatt Power System Interaction Experiment

NO. 7,8,11 /P-2/EI-1
THEME / W.G. / TASK

DATE 04 /29 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Conduct flight test program to determine the extent of the interactions between the space environment and the large surfaces of the megawatt power systems proposed for space systems. These interactions will include the environmental charging interaction as well as the high voltage-space plasma interactions. The data will be used to provide the criteria for designing these systems.

7. ALTERNATIVE APPROACHES/OPTIONS Restrict operating voltage levels of these systems.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Environmental Charging of Spacecraft Surfaces (RTOP 506-23-36); Integrally Regulated Solar Array (RTOP 506-23-30);SPHINX - new initiative, Space Plasma-High Voltage Interaction Study - New Initiative

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
• Project Start							▽													
• Design, Build & Qualify Spacecraft							△	—	—	—	▽									
• Mission											△	—	—	▽						
• Design Criteria														▽						
MANPOWER (M-Y) INHOUSE								20	25	20	15	10	10	2						
CONTRACT																				
FUNDING (10^6 $) INHOUSE								.6	.6	.6	.3	.2	.2	-						
CONTRACT								2.0	3.5	2.5	2.0	-	-	-						

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 1

1. TITLE ENVIRONMENTAL INTERACTIONS: ENVIRONMENTAL CHARGING OF SURFACES

NO. 7,8,9,10,11&12/ P-2/EI-2, THEME / W.G. / TASK

DATE 4 /29/ 76

2. OBJECTIVE

To determine the effects of and means of controlling both the differential and absolute charging by the space environment of the exterior surfaces associated with large satellite systems.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1983]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes (506-23-36 $575K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Non-charging materials development

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED 1. Develop model of interaction for large satellite system surfaces with the environment. 2. Determine charging characteristics and transients induced in systems by discharges as function of materials, size, and environmental conditions (Testing). 3. Determine means of controlling the charging. 4. Extend model from ground test conditions to space conditions. 5. Verify model with space flight. 6. Provide design guidelines for developing power systems for space applications.

5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

LEVEL OF STATE OF ART
1. CONCEPT FORMULATED AND DEFINED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED

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SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Environmental Interactions:
Environmental Charging of Surfaces

NO. 7,8,9,10,11,12/ P-2/EI-2
THEME / W.G. / TASK

DATE 04 /29 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

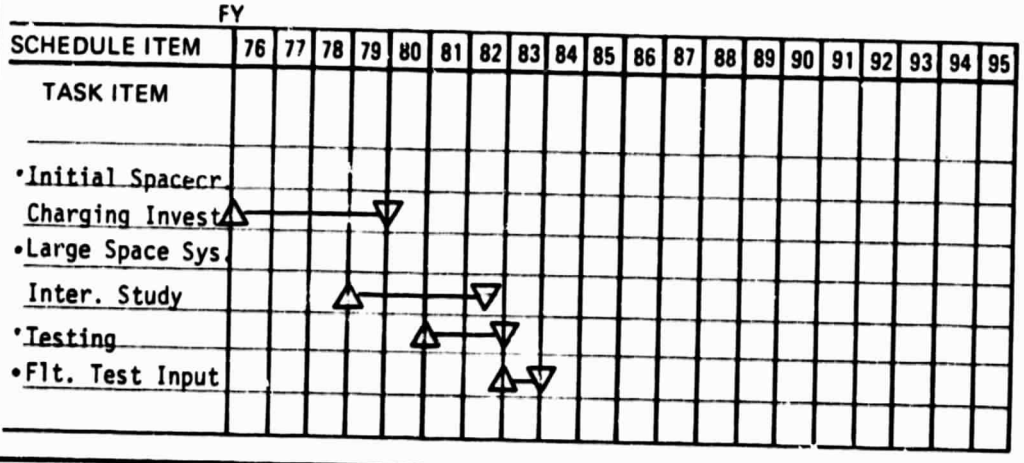
Continue work being conducted under the existing charging investigation (RTOP 506-23-36). Extend investigation by developing models of the charging of large structures proposed for future power systems. Verify models by ground testing. Conduct flight testing to verify behavior in space environment.

7. ALTERNATIVE APPROACHES/OPTIONS None.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Environmental Charging of Spacecraft Surface (RTOP 506-23-36); Megawatt Power System Interaction Experiment (new initiative)

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	8	8	6	4	3	3	3	1												
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.2	.2	.3	.1	.1	.1	.1	-												
CONTRACT	.35	.5	.5	.2	.3	.5	.2	.1												

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 1

ENVIRONMENTAL INTERACTIONS

1. TITLE SPACE PLASMA-HIGH VOLTAGE INTERACTION EXPERIMENT SATELLITES SPHINX B/C (FY-78 New Initiative)

NO. 7,8,9,10,11,12/P-2/EI-3
THEME / W.G. / TASK

DATE 4 / 29 / 76

2. OBJECTIVE

Space flight program to accomplish: flight demonstration of a qualifiable 8 cm ion thruster system for station-keeping applications, obtain space data for design of high voltage system and investigate charge control techniques

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1980]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE No

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY High voltage system technology

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Project Start - October 1977
SPHINX B Review Complete - December 1977
SPHINX C Design Complete - October 1978
SPHINX B Assembled and Test Complete - March 1979
SPHINX C Engineering Model Assembled and Test Completed - 10/79
SPHINX C Protoflight Assembled & Test Completed - August 1980
Launch ready - December 1980

LEVEL OF STATE OF THE ART

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED **FORM NO. I**

TITLE Environmental Interactions:
Space Plasma-High Voltage Interaction
Experiment Satellites (SPHINX B/C)

7,8,9,10
NOTE 12 /P-2/EI-3
THEME / W.G. / TASK

DATE 04 / 29 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Two separate satellites will be designed to accomplish the program objectives. These satellites will be built, tested, qualified and flow on a two year mission in a highly elliptical orbit so that a wide range of plasma densities can be sampled. The flight results will be used to establish the engineering design information for high voltage-space plasma interactions and to provide the flight demonstration of a qualifiable 8-cm ion thruster.

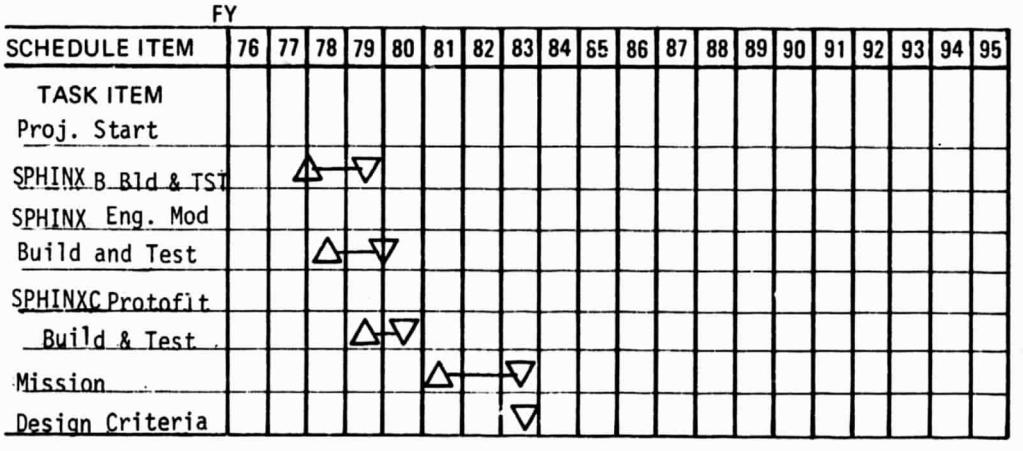
7. ALTERNATIVE APPROACHES/OPTIONS Restrict all large space power systems to relatively low voltage

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Envronmental Charging of Spacecraft Surfaces (506-23-36)

Integrally Regulated Solar Array (506-23-30)

9. TECHNOLOGY SCHEDULES



	78	79	80	81	82	83
MANPOWER (M-Y) INHOUSE	18	21	15	6	5	2
CONTRACT	-	-	-	-	-	-
FUNDING (10^6 $) INHOUSE	.6	.6	.4	.2	.1	.1
CONTRACT	1.4	2.8	1.4	.1	-	-

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE Environmental Interactions: Space Plasma-High Voltage Interaction Experiment Satellites (SPHINX B/C) New Initiative F.Y. 77

NO. A11/P-2/EI-3A
THEME / W.G. / TASK

DATE 04 / 27 / 76

2. OBJECTIVE

Spaceflight program to accomplish: Obtain space data for design of high voltage systems for space, investigate charge control techniques and demonstrate operation of qualifiable 8-cm ion thruster system.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1979]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE No

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY High Voltage System Technology

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

A flight test program is required to provide data on the interactions between the space plasma and the surfaces biased to high voltage. This flight test will cover a broad range of voltages and be tested over a wide range of plasma densities.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Environmental Interactions: Space Plasma-High Voltage Interaction Experiment Satellites (SPHINX B/C)

NO. 7,8,9,10 11,12 /P-2/EI-3A
THEME / W.G. / TASK

DATE 04/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

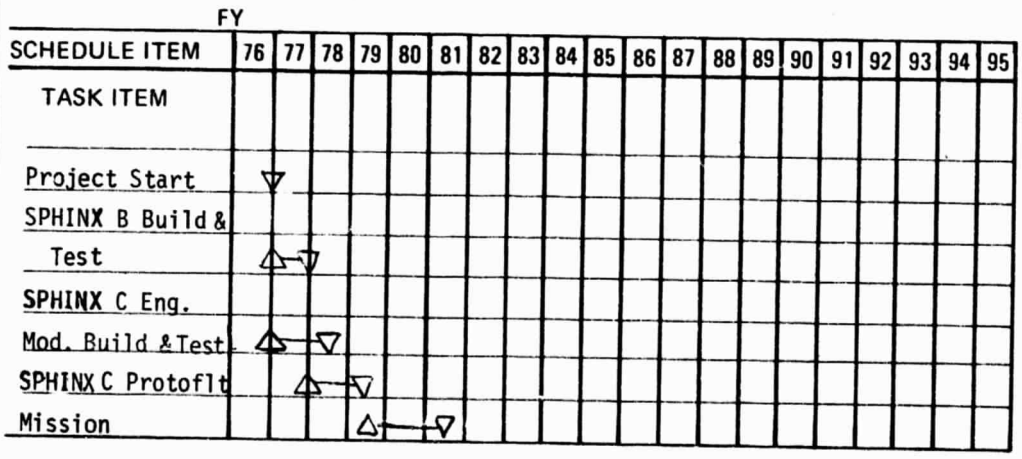
Two separable satellites will be designed to accomplish the program objectives. These satellites will be built, tested, qualified and flown on a two year mission in a highly elliptical orbit. The flight results will be used to establish the extent of the space plasma-high voltage surface interaction, to provide the initial design criteria and to provide the flight demonstration of a qualifiable station keeping/attitude control ion thruster.

7. ALTERNATIVE APPROACHES/OPTIONS Restrict all large space power systems to low voltage levels so that interactions with environment are minimal or insulate from environment.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Environmental Charging of Spacecraft Surfaces (RTOP 506-23-36)
Integrally Regulated Solar Array (RTOP 506-23-36)
Space Plasma-High Voltage Interaction Study - New Initiative

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE		50	50	20	10	5														
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE		.6	.6	.4	.3	.1														
CONTRACT		3.5	2.0	.2	-	-														

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE Environmental Interactions: Space Plasma-High Voltage Interaction Study

NO. All/P-2/EI-4
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

To determine the effects of and means of controlling the interactions between the space environment and the surfaces biased by the space power systems.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 79]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE Yes (New Initiative)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY High Voltage System Technology

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- Develop model of the interaction between the plasma environment and the charged surfaces.
- Verify model by testing.
- Extend model from ground test conditions to space.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Environmental Interactions: Space Plasma-High Voltage Interaction Study

NO. All /P-2/EI-4
THEME / W.G. / TASK

DATE 04 /26 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Conduct analytical and experimental study to develop and verify model of high voltage surface-space plasma interactions for the range of voltages and orbital conditions proposed for space power systems in the early 80's. Flight data will be used in this study to extend model to large, megawatt space power systems of the 90's.

7. ALTERNATIVE APPROACHES/OPTIONS Restrict All Space Power Systems Operations to Relatively Low Voltages.

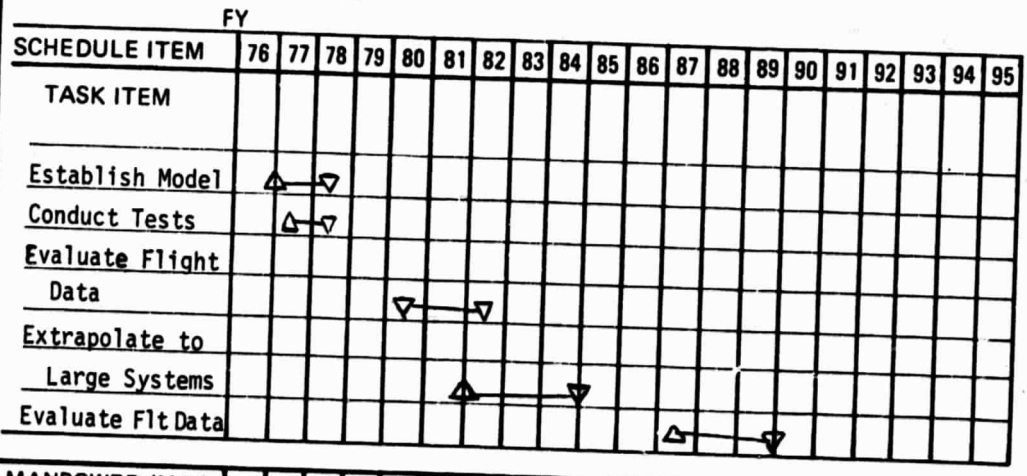
8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Environmental Charging of Spacecraft Surfaces (RTOP 506-23-36)

Integrally Regulated Solar Array (RTOP 506-23-30)

Space Plasma-High Voltage Interaction Experiment Satellites (SPHINX B/c - new initiative

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE		2	2		2	2	2	1	1			1	2	2						
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE		.1	.05		.1	.05	.05	.02	.02			.02	.05	.05						
CONTRACT		.10	.1			.2	.2	-	-				.2	.2						

LEVEL OF STATE OF ART

1 BASIC PHENOMENA OBSERVED AND REPORTED
2 THEORY FORMULATED TO DESCRIBE PHENOMENA
3 THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4 PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5 COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6 MODEL TESTED IN AIRCRAFT ENVIRONMENT
7 MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 1 OF 2

1. TITLE Environmental Interactions: Personnel Shielding by Electromagnetic and Electrostatic Fields

NO. 7, 8/P-2/EI-5
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Evaluate the relative merits of future shielding by electromagnetic or electrostatic fields compared to mass shielding and recommend advanced technology direction.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1995]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes: New Start

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY (a) Superconducting magnet, (b) spacecraft charge control

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Provide detailed design specifications for personnel shielding of large GSO space stations against natural radiation environment. Accomplish laboratory testing to verify the specifications.

SPACE TECHNOLOGY NEED FORM NO. I

TITLE Environmental Interactions: Personnel Shielding By Electromagnetic or Electrostatic Fields

NO. 1,7,8/P-2/EI-5
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(a) Survey of environment.
(b) Analysis of shielding requirements.
(c) Analysis of field generation requirements.
(d) Experimental field generation.
(e) Technology comparisons.
(f) Selection of shielding method.

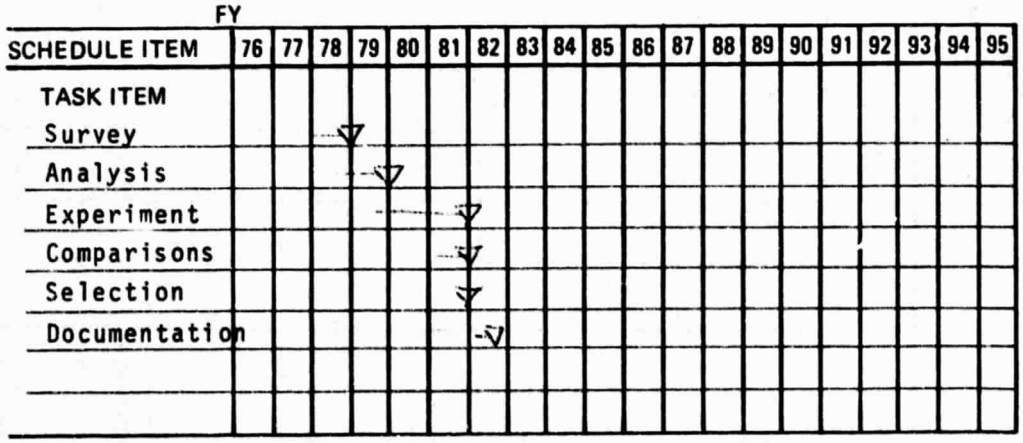
7. ALTERNATIVE APPROACHES/OPTIONS

Mass shielding

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)			2	2	4	4	2													
INHOUSE																				
CONTRACT																				
FUNDING (10^6 $)			.2	.2	.3	.3	.2													
INHOUSE																				
CONTRACT			.1	.2	.3	.4	.1													

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

(List in numerical order, 1 — Highest Priority)

FORM II
FORM III

WORKING GROUP P-2

DATE 4 /29 / 76

Task No.	TECHNOLOGY NEED NO. / THEME NO.	7 SPACE POWER 83	7 SPACE POWER 88	8 SPACE INDUST. 83	8 SPACE INDUST. 88	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV. TRANS. SYS.	NASA R&T Current	NASA R&T R&T Base	SUMMARY PRIORITY ASSESSMENT WG	TT	OAST DIV.	
PC-2	Lt. Wt. Rad. Resis. S.A.		2		2	2		9		x	x	5			
PC-4	Lt. Wt. Lo Cost Silicon Arrays		6		6	6	4	8		x	x	11			
PC-7	Solar Array Tech. for SEP and P/L Appl.	3		3			4	1	8	x	x	4			
PC-8	Sil. Solar Cell Tech.					7	4	7		x	x	10			
ES-1	Tech. for Improving Perf. & Life:Alk. Batt.		13		13	13	3	5		x	x	13			
ES-2	Silver-Hydrogen Rechargable Battery							11		x	x	33			
ES-3	Long Life, Lt. Wt. Ni-Cd Battery						3	2	7	x	x	12			
ES-5	Primary Probe Batteries						3			x	x	21			
ES-6	Large Ni-Cd Battery	4		4				10			x	6			
ES-7	Advanced Regen. H-O Fuel Cell					4					x	23			
ES-8	Photovoltaic/Electrolysis Fuel Cell Tech.		5		5	3					x	22			
ECC-1	Lightweight Fuel Cell								1	x	x	24			
PP-1	Advan. Electronic P.C. Technology	8	12	8	12	5		3	6	x	x	15			

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
FORM III

(List in numerical order, 1 — Highest Priority)

WORKING GROUP P-2

DATE 4 / 29 / 76

Task No.	TECHNOLOGY NEED NO. / THEME NO.	7 SPACE POWER 83	7 SPACE POWER 88	8 SPACE INDUST. 83	8 SPACE INDUST. 88	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV. TRANS. SYS.	NASA R&T Current	NASA R&T R&T Base	SUMMARY PRIORITY ASSESSMENT WG	TT	OAST DIV.	
PP-2	Integrally Regul. Solar Array Tech.							13	2	x	x	16			
PP-3	Hi Power/Hi Voltage/ Low Loss Components	7	8	7	8				3	x	x	7			
PP-5	Remote Power Controller Tech.	10		10		10		6	4	x	x	25			
PP-6	Lg. Life, Hi Perf. Pwr. Proc. for Planetary Appl.						2			x	x	17			
PP-7	Power Transfer Across Rotary Joints							12			x	32			
PP-8	Multi-Kilowatt Distribution System	6	10	6	10			4		x	x	9			
TE-1	Thermoelectric Systems						3			x	x	18			
TE-3	Nuclear Thermionic Space Power System					12	1			x	x	26			
TE-5	Hi Performance Thermionic Conv. Tech.								5	x	x	27			
TE-7	Heat Pipes for High Thermal Densities	9	11	9	11					x	x	28			
TX-1	Microwave Transmission	5		5						x	x	14			
TX-2	Laser Power Converter		4		4					x	x	31			
TX-3	Laser Power Trans.		4		4					x	x	30			

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
FORM III

(List in numerical order, 1 — Highest Priority)

WORKING GROUP P-2

DATE 4 /29 /76

Task No.	THEME NO. / TECHNOLOGY NEED NO.	7 SPACE POWER 83	7 SPACE POWER 88	8 SPACE INDUST. 83	8 SPACE INDUST. 88	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV.TRANS. SYS.	NASA R&T Current	NASA R&T R&T Base	SUMMARY PRIORITY ASSESSMENT WG	TT	OAST DIV.	
S-2	Auto. Power Systems Management (APSM)		7		7	9	2			x	x	8			
S-4	Advanced Power Systems Tech.						2				x	20			
S-6	Oasis	1	1	1	1	8					x	1			
S-7	Auto. Test Techniques and Technology		9		9		2			x	x	29			
EI-2	Environmental Charging of Surfaces					1		14		x	x	19			
EI-3	Sphinx B/C (FY 78 N.I.)		3		3	11						2			
EI-3A	Sphinx B/C (FY 77 N.I.)	2		2											

POWER FORM
P-2

THEME SETI NO. 9

ELECTRICAL POWER REQUIREMENTS

	PERIOD	1984	1990	2000
1.	Total Power KWe	2	3 *(Order-of-megawatt power for shield and dish propulsion not included above)	10
2.	Bus Voltage Regulation %	1	1	1
3.	Special Load Requirements		*Shield and dish propulsion for rotation of 1°/day approximately once a year ± 2°	± 7°
4.	Breakdown Load Reqmnts of (1) Above	Receivers Data Links Control Telemetry Figure Monitors Figure Servos Cryogenics (5 to 100K)	→ 5 to 10°K → *Shield and dish propulsion	
5.	Location of Orbit or Planet i.e. LEO,GSO, INNER or OUTER Planet	LEO/GSO	GSO/Lunar Distance	GSO/Lunar Distance
6.	Unique Environmental Requirements	Half-Time Shadow Environmental-Charging Problem	→	
7.	Operational Life	10 years	10 years	30 years
8.	Autonomous?	Yes →		
9.	Maintenance?	Yes →		
10.	Propulsion Req:			
	a - Transfer Orb.	Yes		→
	b - Position	Yes		→
	c - Planetary			→
11.	Special EMI,RFI etc?	RFI		→
12.	Other			

Power Form
P-2

THEME SOLAR EXPLORATION NO. 10

ELECTRICAL POWER REQUIREMENTS

PERIOD	19 90	19 95	2000
1 • TOTAL POWER - KW_E	• PROPULSIVE POWER - HUNDREDS KW • SCIENCE PAYLOAD - 20 TO 30 KW • TOTAL = 220-230 KW • USE 200 KW	• 400/600 KW OR HIGHER • ABOUT THE SAME SCIENCE PAYLOAD • TOTAL 400-600 KW	? UNDEFINED
2 • BUS VOLTAGE REGULATION %	• FOR THRUST 1000V OR MORE • 100-200V FOR SCIENCE PAYLOAD • ORDER OF 1% DESIRED	• SAME	
3 • SPECIAL LOAD REQUIREMENTS	• PROPULSION SEE (1) ABOVE • SAR HAS PULSE LOADS CABLE RUNS LONG 60-80 FT	• SAME	
4 • BREAKDOWN LOAD REQUIREMENTS OF (1) ABOVE	• SEE (1)	• SEE (1)	
5 • LOCATION OF ORBIT OR PLANET i.e., LEO, GSO, INNER OR OUTER PLANET	• EARTH ORBIT OF PLANET TEST 10 KGM FACILITY - IN LEO - 30 TO GSO • LEO 100-300 MILES FOR MONTHS • TRANSFER TIME - MONTHS WITH NEP AND SEP (60-180 DAYS)	• LAUNCH 1ST FACILITY TO OUTER PLANETS - 10 KGM NOT INCLUDING PROPULSION (12KG) INCLUDING PROBES, LANDER & PENETRATORS. 5 KG FOR ORBITING FACILITY	
6 • UNIQUE ENVIRONMENTAL REQUIREMENT REQUIREMENTS	• EARTH RADIATION ENVIRONMENT • POSSIBLE SCALED-DOWN NEP* RADIATION ENVIRONMENT *1988 AVAILABILITY	• SEVERE JUPITER RADIATION ENVIRONMENT	
7 • OPERATIONAL LIFE 8 • AUTONOMOUS? 9 • MAINTENANCE?	• 8-10 YEARS • YES! • OCCASIONALLY MANNED VISITS	• 20 YEARS (TO EOM) • YES • UNMANNED RESUPPLY & SAMPLE RETURN EVERY 3-5 YEARS	

Power Form
P-2

THEME SOLAR EXPLORATION (CONTINUED) NO. 10

ELECTRICAL POWER REQUIREMENTS

PERIOD	19 90	19 95	2000
10 • PROPULSION REQ: a. Transfer Orbit b. Position c. Planetary	• YES • LEO TO GSO/STATION KPG • N/A	• 1ST LAUNCH USES NEP: SO DOES RESUPPLY • NEP & CHEMICAL FOR LANDERS, PROBES, FREE FLYERS (MANY)	
11 • SPECIAL EMI, RFI, ETC.?	• YES, SHIELD RADIATION OF NEP-LARGE PULSED POWER	• JUPITER IS A STRONG RFI SOURCE IN LITERATURE (SYNCHROTRON)	
12 • OTHER	• FREE FLYER - - Chemical Propulsion - Few Hundred Watts from RTG	• CHEMICAL/SEP WOULD PRECLUDE MISSIONS BEYOND JUPITER - THUS NEP ONLY OPTION • SUPPORT TO ORBITER: (a) Penetrators with - RTG: 1-2 watts; 20,000g impact capability; 1-2 yrs life BATTERY: 10 watt load for 5-10 mins., 1 or 2 times month for 1-2 yrs temp. of about -150K (Jupiter env.) and work after 20 years - need batteries (long life) (b) Landers and probes using battery and RTG (c) Photo reconnaissance satellite needs 50 watt RTG, 1 month life, perform in intense radiation environment provide power after 20 years. (d) Sample & return - use RTG and battery. High peak battery loads to hundreds of watts.	

DATE